

**1997 Thomas Built Bus  
into a Flat Frontal Barrier  
TRC Test Number: 990421-1**

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**Final Report  
April - June 1999**

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Section 1.0

Purpose and Test Procedure

## Purpose and Test Summary

The overall objective of this test program is the evaluation and /or development of school bus safety systems. This 30 mph flat barrier impact test was conducted to generate both vehicle and occupant dynamics in order to develop a frontal crash profile for subsequent HYGE sled testing.

The test was conducted with a 1997 Thomas Built Bus obtained from General Testing Laboratories (GTL). The vehicle had previously been used as a FMVSS 301 test vehicle. The test vehicle contained two instrumented Hybrid III 50<sup>th</sup> percentile adult male dummies; two instrumented Hybrid III 5<sup>th</sup> percentile adult female dummies; two instrumented 6 year old child dummies; and two uninstrumented 50<sup>th</sup> percentile adult male ballast dummies.

Section 2.0

Frontal Barrier Impact Test Summary

## Test Procedure

This test was conducted per VRTC personnel's instructions. Data was obtained relative to FMVSS 208, "Occupant Crash Protection," performance.

The test vehicle was instrumented with twelve (12) accelerometers to measure longitudinal, lateral, and vertical axis accelerations. The vehicle's specified impact velocity range was 29.5 to 30.5 mph. The vehicle impacted a flat frontal barrier.

The test vehicle contained six (6) instrumented anthropomorphic test devices (dummies) and four (4) uninstrumented anthropomorphic test devices (dummies). The dummies were positioned according to Figure 1.

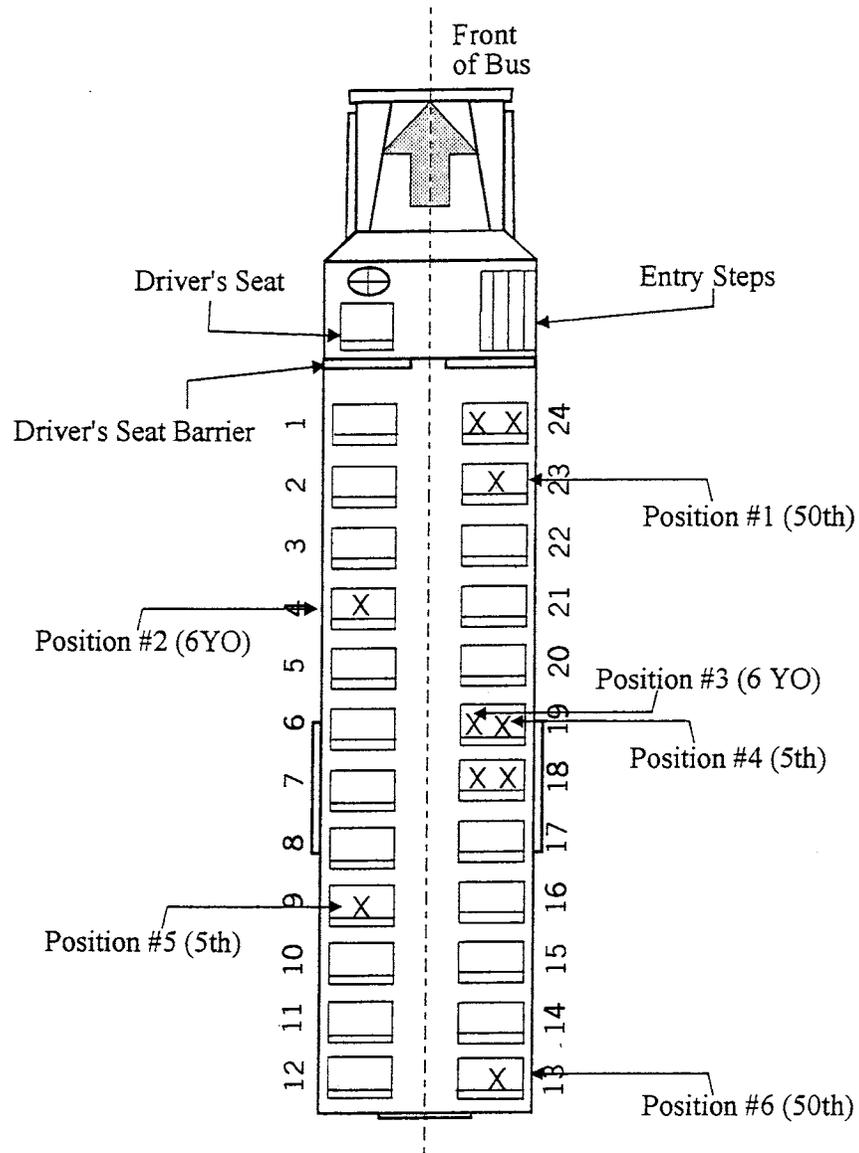
The dummies were instrumented with head, chest, and pelvis accelerometers to measure longitudinal, lateral, and vertical accelerations; chest deflection potentiometers; left and right femur load cells to measure axial forces; and upper neck load cells to measure forces and moments.

The one hundred-twenty (120) data channels were digitally sampled at 12,500 samples per second and processed per Sections 11.13 through 11.15 of the Laboratory Test Procedure.

The crash event was recorded by one (1) real-time panning motion picture camera and fourteen (14) high-speed motion picture cameras. The pre-test and post-test conditions were recorded by one (1) real-time motion picture camera.

The vehicle and occupant data are summarized in Section 2.0. The FMVSS 208 data are presented in Section 3.0. The vehicle, occupant, and camera measurements are presented in Section 4.0. Appendix A contains the still photographic prints. Appendix B contains the dummy and vehicle data plots. Appendix C contains the dummy calibration information.

Figure 1 Dummy Positioning Data



## Test Results Summary

This flat frontal barrier test was conducted at TRC on April 21, 1999.

The test vehicle was a 1997 Thomas Built Bus. The vehicle's test weight was 17,760 pounds. The vehicle's impact speed was 30.0 mph. The vehicle's maximum static crush was 206 millimeters.

*Comparison  
with previous test  
L/R or low*

The Position #1 dummy's 36 milliseconds Head Injury Criteria (HIC) was 244. The Position #1 dummy's chest maximum resultant acceleration with three (3) milliseconds minimum duration was 26.0 g. The Position #1 dummy's chest deflection was 4 mm. The Position #1 dummy's left and right femur maximum compressive forces were 2704 N and 2708 N, respectively.

The Position #2 dummy's 36 milliseconds HIC was 175. The Position #2 dummy's chest maximum resultant acceleration with three (3) milliseconds minimum duration was 30.8 g. The Position #2 dummy's chest deflection was 4 mm. The Position #2 dummy's left and right femur maximum compressive forces were 1270 N and 9028 N, respectively.

The Position #3 dummy's 36 milliseconds HIC was 280. The Position #3 dummy's chest maximum resultant acceleration with three (3) milliseconds minimum duration was 33.1 g. The Position #3 dummy's chest deflection was 4 mm. The Position #3 dummy's left and right femur maximum compressive forces were 1150 N and 1855 N, respectively.

The Position #4 dummy's 36 milliseconds HIC was 112. The Position #4 dummy's chest maximum resultant acceleration with three (3) milliseconds minimum duration was 23.2<sup>1</sup> g. The Position #4 dummy's chest deflection was 4 mm. The Position #4 dummy's left and right femur maximum compressive forces were 2996 N and 2769 N, respectively.

The Position #5 dummy's 36 milliseconds HIC was 330. The Position #5 dummy's chest maximum resultant acceleration with three (3) milliseconds minimum duration was 22.6 g. The Position #5 dummy's chest deflection was 5 mm. The Position #5 dummy's left and right femur maximum compressive forces were 3287 N and 2274 N, respectively.

The Position #6 dummy's 36 milliseconds HIC was 153. The Position #6 dummy's chest maximum resultant acceleration with three (3) milliseconds minimum duration was 22.3 g. The Position #6 dummy's chest deflection was 4 mm. The Position #6 dummy's left and right femur maximum compressive forces were 4271 N and 2956 N, respectively.

<sup>1</sup> See Data Acquisition Explanations

## Data Acquisition Explanations

The Position #1 dummy's neck moment about Y-axis data channel, NEKYM1, exceeded its data channel's full scale input between approximately 130 and 140 milliseconds. This affected the calculation for the moment about the occipital condyle for the Position #1 dummy.

The Position #1 dummy's pelvis X-axis acceleration data channel, PEVXG1, recorded questionable data throughout the event. This affected the resultant calculation for the Position #1 dummy's pelvis.

The Position #2 dummy's right femur force data channel, RFMF2, recorded questionable data spikes at approximately 25, 128, and 154 milliseconds.

The Position #4 dummy's chest X-axis acceleration data channel, CSTXG4, recorded questionable data throughout the event. This affected the resultant calculation for the Position #4 dummy's chest.

The Position #4 dummy's pelvis X-axis acceleration data channel, PEVXG4, recorded questionable data spikes at approximately 57 and 100 milliseconds. This affected the resultant calculation for the Position #4 dummy's pelvis.

The Position #4 dummy's pelvis Y-axis acceleration data channel, PEVYG4, recorded questionable data throughout the event. This affected the resultant calculation for the Position #4 dummy's pelvis.

Table 1 Crash Test Summary

Test type:	Frontal barrier impact
Test date:	04/21/99
Test time:	1822
Ambient temperature at impact area:	21° C
Vehicle year/make/ model/body style:	1997/Thomas Built/Bus
Vehicle test weight:	17,760 lbs
Impact angle <sup>1</sup> :	0°
Impact velocity <sup>2</sup> :	
Primary:	30.0 mph
Secondary:	N/A
Maximum static crush:	8.1 in
Average rebound:	8.9 in
Number of cameras:	
Real-time:	1
High-speed:	14
Door opening data:	
Left-front:	N/A
Right-front:	N/A

<sup>1</sup> With respect to tow track centerline.

<sup>2</sup> Speed trap measurement ( $\pm .08$  km/h accuracy)

Table 2 Test Vehicle Information

Vehicle year/make/  
model/body style: 1997/Thomas Built/Bus

Color: Yellow

VIN: 4UZ3CFFA5VC749501

Engine data:

Placement: Longitudinal

Cylinders: 6

Displacement: 5.9 liters

Transmission data: 4 speed, \_\_\_ manual, X automatic, \_\_\_ overdrive

Final drive: \_\_\_ fwd, X rwd, \_\_\_ 4wd

Date vehicle received: N/A

Odometer reading: N/A

Dealer's name and address: N/A

Accessories:

Power steering	Yes	Automatic transmission	Yes
Power brakes	Yes	Automatic speed control	No
Power seats	No	Tilting steering wheel	No
Power windows	No	Telescoping steering wheel	No
Tinted glass	No	Air conditioning	No
Radio	No	Anti-skid brake	No
Clock	No	Rear window defroster	No
Power door locks	No	Other:	None

Certification data from vehicle's label:

Vehicle manufactured by: Thomas Built

Date of manufacture: 11/96

VIN: 4UZ3CFFA5VC749501

GVWR: 29,000 lbs

GAWR: Front: 10,000 lbs

Rear: 19,000 lbs

Table 2 Test Vehicle Information, Cont'd.

Size of tires on vehicle:	11R x 22.5
Spare tire:	N/A
Type of front seats:	N/A

Tire & capacity data from vehicle's label:

Recommended tire size:	22.5 x 8.25
Recommended cold tire pressure:	
Front:	100 psi
Rear:	100 psi
Designated Seating Capacity:	
Front	N/A
Rear	N/A
Total	N/A
Vehicle Cargo Weight:	N/A

Table 2 Test Vehicle Information, Cont'd.

Weight of test vehicle as received (with maximum fluids):

Right front	N/A	Right rear	N/A
Left front	N/A	Left rear	N/A
Total front weight	N/A	(N/A% of total vehicle weight)	
Total rear weight	N/A	(N/A% of total vehicle weight)	
Total delivered weight	N/A		

Calculation of test vehicle's target test weight:

RCLW = Rated Cargo and Luggage Weight

UDW = Unloaded Delivered Weight

DSC<sup>1</sup> = Designated Seating Capacity

RCLW<sup>2</sup> = N/A

Target test weight = UDW + RCLW + (number of Hybrid III Dummies x 75.7 kg per dummy)

Target test weight<sup>3</sup> = N/A

Weight of test vehicle with required dummies:

Front 10,380 lbs

Rear 7,380 lbs

Total 17,760 lbs

Weight of ballast secured in vehicle: None

Components removed to meet target test weight: None

CG rearward of front wheel centerline: 114 in

Vehicle Wheelbase: 274.2 in

<sup>1</sup> The designated seating capacity is determined by counting the number of seat belts installed in the vehicle.

<sup>2</sup> From vehicle's tire label.

<sup>3</sup> There was no target test weight provided.

Table 3 Post-Impact Data

Test number: 990421-1  
Test date: 04/21/99  
Test time: 1822  
Test type: Frontal barrier impact  
Impact angle: 0°  
Ambient temperature at impact area: 21° C  
Temperature in occupant compartment: 18° C  
Impact velocity:  
Cable speed: 30.0 mph  
Specified range: 29.5 to 30.5 mph

Test vehicle static crush:

Overall length of test vehicle:

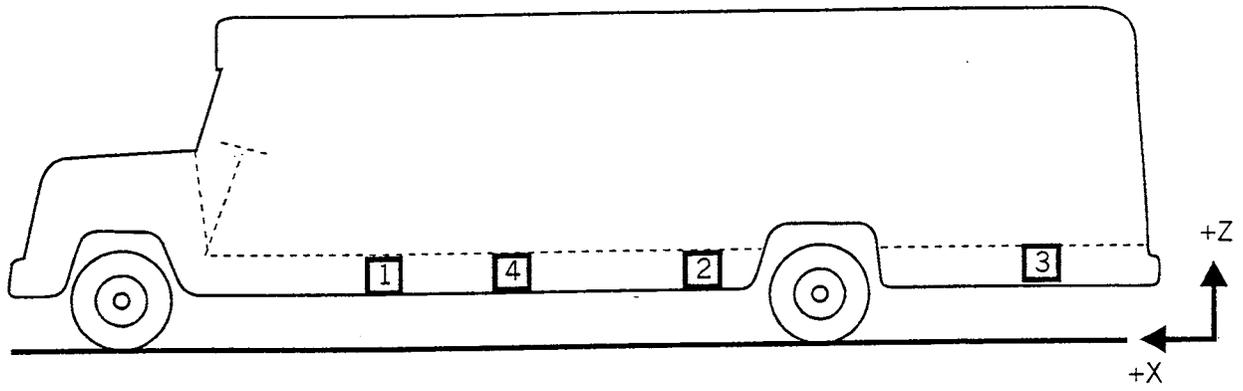
Pre-test:	L: 428.4 in	C: 442.9 in	R: 430.1 in
Post-test:	L: 427.6 in	C: 435.1 in	R: 425.3 in
Total crush:	L: 0.8 in	C: 7.8 in	R: 4.8 in
Average crush:	4.5 in		

Test vehicle rebound from flat barrier:

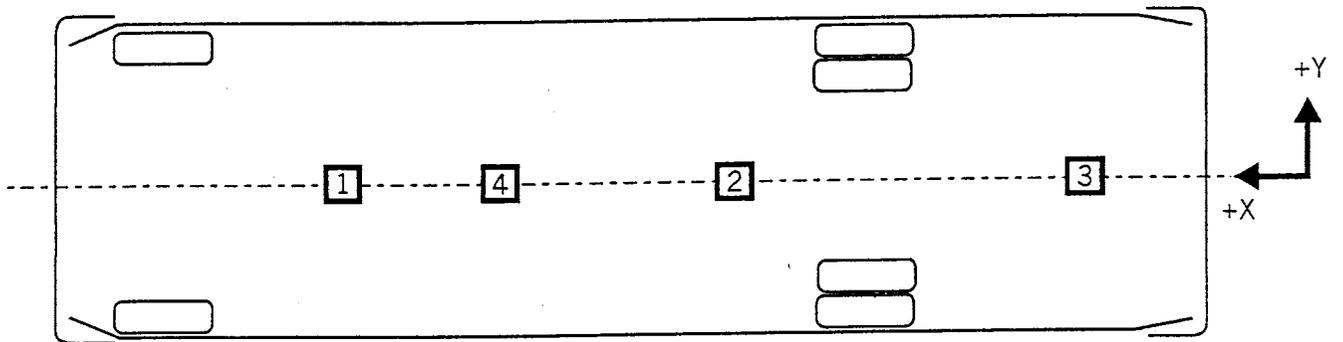
Distance from test vehicle to barrier:

Post-test:	L: N/A	C: 8.9 in	R: N/A
Average rebound:	8.9 in		

Figure 2 Vehicle Accelerometer Placement



Side View



Bottom View

Table 4 Vehicle Accelerometer Locations and Data Summary

TEST NUMBER: 990421-1	X	Y	Z	POSITIVE DIRECTION	NEGATIVE DIRECTION
No. LOCATION					
1 FLOOR TUNNEL #1	NA	NA	NA		
LONGITUDINAL				1.1 g @ 257.3 ms	23.6 g @ 76.3 ms
LATERAL				4.7 g @ 187.6 ms	12.5 g @ 63.2 ms
VERTICAL				25.4 g @ 72.9 ms	39.9 g @ 76.6 ms
RESULTANT				46.7 g @ 76.5 ms	
2 FLOOR TUNNEL #2	NA	NA	NA		
LONGITUDINAL				5.8 g @ 15.4 ms	21.4 g @ 51.1 ms
LATERAL				4.4 g @ 98.6 ms	10.9 g @ 67.5 ms
VERTICAL				37.2 g @ 24.5 ms	34.5 g @ 50.3 ms
RESULTANT				39.2 g @ 50.5 ms	
3 FLOOR TUNNEL #3	NA	NA	NA		
LONGITUDINAL				2.1 g @ 218.2 ms	17.3 g @ 135.0 ms
LATERAL				5.8 g @ 105.6 ms	6.3 g @ 26.6 ms
VERTICAL				44.9 g @ 86.6 ms	38.9 g @ 91.4 ms
RESULTANT				45.3 g @ 86.6 ms	
4 VEHICLE CENTER OF GRAVITY	NA	NA	NA		
LONGITUDINAL				4.5 g @ 68.4 ms	16.2 g @ 136.5 ms
LATERAL				4.4 g @ 159.1 ms	11.9 g @ 64.1 ms
VERTICAL				50.9 g @ 63.9 ms	51.4 g @ 69.3 ms
RESULTANT				53.4 g @ 63.9 ms	

REFERENCE: X: + FORWARD FROM REAR BUMPER  
 Y: + LEFTWARD FROM VEHICLE CENTERLINE  
 Z: + UPWARD FROM GROUND LEVEL

Section 3.0

FMVSS 208 Data

Table 5 Dummy Injury Criteria

		<u>Maximum Acceleration</u>						
		Head				Chest		
		X	Y	Z	R	X	Y	Z
Position #1								
Dummy		-79.0 g	-6.9 g	20.2 g	79.4 g	-26.2 g	3.4 g	11.7 g

<u>Maximum Femur Compressive Force</u>		
	Left Femur	Right Femur
Position #1 Dummy	2704 N	2708 N

<u>36 millisecond Head Injury Criteria</u>			
	HIC	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #1 Dummy	244	120.3 ms	130.9 ms

<u>Chest Maximum Resultant Acceleration<sup>2</sup></u>			
	Acceleration	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #1 Dummy	26.0 g	135.9 ms	139.0 ms

<u>Maximum Chest Deflection</u>	
Position #1 Dummy	4 mm

<sup>1</sup> As defined in FMVSS No. 208

<sup>2</sup> Defined as equal to or exceeding 0.003 sec. duration

Table 5 Dummy Injury Criteria, Cont'd.

	<u>Maximum Acceleration</u>						
	Head				Chest		
	X	Y	Z	R	X	Y	Z
Position #2 Dummy	-50.3 g	-8.6 g	25.7 g	54.9 g	-27.1 g	4.5 g	18.4 g

	<u>Maximum Femur Compressive Force</u>	
	Left Femur	Right Femur <sup>3</sup>
Position #2 Dummy	1270 N	9028 N

	<u>36 millisecond Head Injury Criteria</u>		
	HIC	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #2 Dummy	175	141.4 ms	177.4 ms

	<u>Chest Maximum Resultant Acceleration<sup>2</sup></u>		
	Acceleration	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #2 Dummy	30.8 g	156.3 ms	159.4 ms

	<u>Maximum Chest Deflection</u>
Position #2 Dummy	4 mm

<sup>1</sup> As defined in FMVSS No. 208

<sup>2</sup> Defined as equal to or exceeding 0.003 sec. Duration

<sup>3</sup> See Data Acquisition Explanations

Table 5 Dummy Injury Criteria, Cont'd.

	<u>Maximum Acceleration</u>						
	Head				Chest		
	X	Y	Z	R	X	Y	Z
Position #3 Dummy	-77.6 g	-11.8 g	31.7 g	83.8 g	-24.5 g	-4.0 g	33.0 g

	<u>Maximum Femur Compressive Force</u>	
	Left Femur	Right Femur
Position #3 Dummy	1150 N	1855 N

	<u>36 millisecond Head Injury Criteria</u>		
	HIC	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #3 Dummy	280	141.0 ms	176.9 ms

	<u>Chest Maximum Resultant Acceleration<sup>2</sup></u>		
	Acceleration	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #3 Dummy	33.1 g	173.0 ms	176.1 ms

	<u>Maximum Chest Deflection</u>
Position #3 Dummy	4 mm

<sup>1</sup> As defined in FMVSS No. 208

<sup>2</sup> Defined as equal to or exceeding 0.003 sec. duration

Table 5 Dummy Injury Criteria, Cont'd.

	<u>Maximum Acceleration</u>						
	Head				Chest		
	X	Y	Z	R	X	Y	Z
Position #4 Dummy	-42.9 g	76.4 g	36.0 g	89.5 g	-70.3 <sup>3</sup> g	9.8 g	19.8 g

	<u>Maximum Femur Compressive Force</u>	
	Left Femur	Right Femur
Position #4 Dummy	2996 N	2769 N

	<u>36 millisecond Head Injury Criteria</u>		
	HIC	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #4 Dummy	112	113.8 ms	133.7 ms

	<u>Chest Maximum Resultant Acceleration<sup>2</sup></u>		
	Acceleration	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #4 Dummy	23.2 <sup>3</sup> g	145.0 ms	148.1 ms

	<u>Maximum Chest Deflection</u>
Position #4 Dummy	4 mm

<sup>1</sup> As defined in FMVSS No. 208

<sup>2</sup> Defined as equal to or exceeding 0.003 sec. duration

<sup>3</sup> See Data Acquisition Explanations

Table 5 Dummy Injury Criteria, Cont'd.

	<u>Maximum Acceleration</u>						
	Head				Chest		
	X	Y	Z	R	X	Y	Z
Position #5 Dummy	-91.9 g	5.8 g	-20.4 g	93.7 g	-18.3 g	5.4 g	14.4 g

	<u>Maximum Femur Compressive Force</u>	
	Left Femur	Right Femur
Position #5 Dummy	3287 N	2274 N

	<u>36 millisecond Head Injury Criteria</u>		
	HIC	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #5 Dummy	330	120.6 ms	128.6 ms

	<u>Chest Maximum Resultant Acceleration<sup>2</sup></u>		
	Acceleration	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #5 Dummy	22.6 g	149.3 ms	152.3 ms

	<u>Maximum Chest Deflection</u>
Position #5 Dummy	5 mm

<sup>1</sup> As defined in FMVSS No. 208

<sup>2</sup> Defined as equal to or exceeding 0.003 sec. duration

Table 5 Dummy Injury Criteria, Cont'd.

	<u>Maximum Acceleration</u>						
	Head				Chest		
	X	Y	Z	R	X	Y	Z
Position #6 Dummy	-47.7 g	8.4 g	16.3 g	48.1 g	-20.9 g	-1.8 g	9.7 g

	<u>Maximum Femur Compressive Force</u>	
	Left Femur	Right Femur
Position #6 Dummy	4271 N	2956 N

	<u>36 millisecond Head Injury Criteria</u>		
	HIC	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #6 Dummy	153	124.6 ms	142.6 ms

	<u>Chest Maximum Resultant Acceleration<sup>2</sup></u>		
	Acceleration	Time t <sub>1</sub>	Time t <sub>2</sub>
Position #6 Dummy	22.3 g	140.6 ms	143.6 ms

	<u>Maximum Chest Deflection</u>
Position #6 Dummy	4 mm

<sup>1</sup> As defined in FMVSS No. 208

<sup>2</sup> Defined as equal to or exceeding 0.003 sec. duration

Section 4.0

Vehicle, Occupant, and Camera Measurements

Figure 3 Pre-test and Post-test Measurement Points

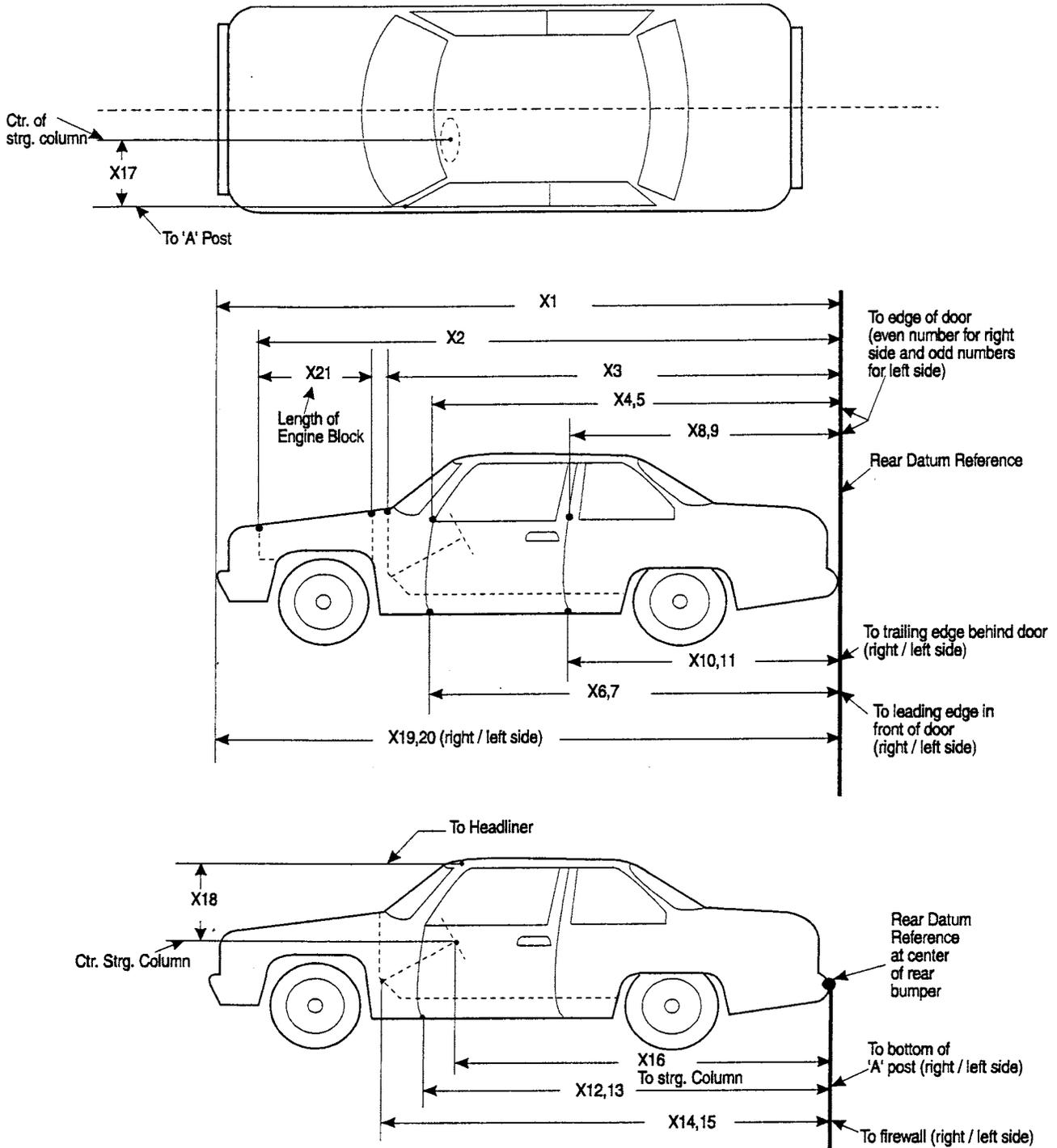


Table 6 Impacted Vehicle Measurements

Vehicle year/make/model/body style: 1997/Thomas Built/Bus

Test Number: 990421-1

No.	Type of measurement	Pre-Test	Post-Test	Difference
X1	Total Length of Veh. at Centerline	442.9	435.1	7.8
X2	Rear Surface of Veh. to Front of Engine Block	422.5	428.5	-6.0
X3	Rear Surface of Veh. to Firewall	394.0	419.5	-25.5
X4	Rear Surface of Veh. to Upper Leading Edge of Right Door	374.0	390.6	-16.6
X5	Rear Surface of Veh. to Upper Leading Edge of Left Door	N/A	N/A	N/A
X6	Rear Surface of Veh. to Lower Leading Edge of Right Door	373.5	387.7	-14.2
X7	Rear Surface of Veh. to Lower Leading Edge of Left Door	N/A	N/A	N/A
X8	Rear Surface of Veh. to Upper Trailing Edge of Right Door	337.9	382.0	-44.1
X9	Rear Surface of Veh. to Upper Trailing Edge of Left Door	N/A	N/A	N/A
X10	Rear Surface of Veh. to Lower Trailing Edge of Right Door	337.8	369.7	-31.9
X11	Rear Surface of Veh. to Lower Trailing Edge of Left Door	N/A	N/A	N/A
X12	Rear Surface of Veh. to Bottom of " A " Post on Right Side	372.8	390.4	-17.6
X13	Rear Surface of Veh. to Bottom of " A " Post on Left Side	372.8	417.5	-44.7
X14	Rear Surface of Veh. to Firewall--Right Side	389.7	416.2	-26.5
X15	Rear Surface of Vehicle to Firewall --Left Side	390.2	426.4	-36.2
X16	Rear Surface of Veh. to Steering Wheel Center	365.3	391.0	-25.7
X17	Center of Steering Column to " A " Post	29.0	28.0	1.0
X18	Center of Steering Column to Headliner	29.6	36.8	-7.2
X19	Rear Surface of Veh. to Right Side of Front Bumper	430.1	425.3	4.8
X20	Rear Surface of Veh. to Left Side of Front Bumper	428.4	427.6	0.8
X21	Length of Engine Block	29.0	29.0	0

Figure 4 Vehicle Target Locations

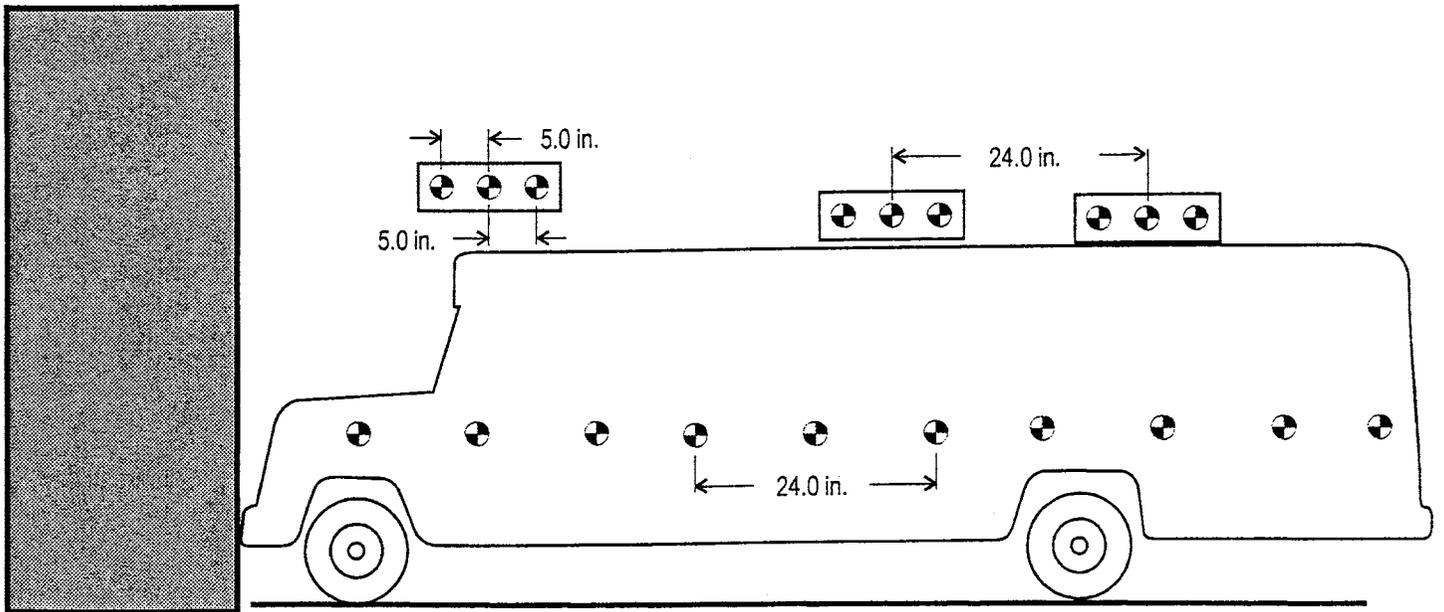


Table 7 Dummy Measurement Data For Bus Seat Occupants

All measurements are referenced to the front outboard seat mounting belt.

**Placement of Left Side, Instrumented 6-Yr.-Old Dummy:**

Bus seat #4

Distance from bus seat back hinge to head CG	x:	-344	y:	345	z:	879
Distance from bus seat back hinge to H-point	x:	-315	y:	325	z:	442
Distance from bus seat back hinge to knee pivot	x:	-47	y:	325	z:	489

**Placement of Left Side, Instrumented HIII 5<sup>th</sup> Female Dummy:**

Bus seat #9

Distance from seat back hinge to head CG	x:	-307	y:	110	z:	1025
Distance from seat back hinge to H-point	x:	-195	y:	30	z:	445
Distance from seat back hinge to knee pivot	x:	110	y:	30	z:	423

**Placement of Right Side, Instrumented 6-Yr.-Old Dummy:**

Bus seat #19

Distance from seat back hinge to head CG	x:	-360	y:	-120	z:	887
Distance from seat back hinge to H-point	x:	-290	y:	-75	z:	422
Distance from seat back hinge to knee pivot	x:	-25	y:	-75	z:	460

**Placement of Right Side, Instrumented HIII 5<sup>th</sup> Female Dummy:**

Bus seat #19

Distance from seat back hinge to head CG	x:	-210	y:	-620	z:	1035
Distance from seat back hinge to H-point	x:	-265	y:	-450	z:	460
Distance from seat back hinge to knee pivot	x:	70	y:	-480	z:	410

**Placement of Right Side, Instrumented HIII 50<sup>th</sup> Male Dummy:**

Bus seat #23

Distance from seat back hinge to head CG	x:	-240	y:	-385	z:	1112
Distance from seat back hinge to H-point	x:	-270	y:	-250	z:	462
Distance from seat back hinge to knee pivot	x:	155	y:	-290	z:	507

Table 7 Dummy Measurement Data For Bus Seat Occupants, Cont'd.

All measurements are referenced to the front outboard seat mounting belt.

**Placement of Right Side, Instrumented HIII 50<sup>th</sup> Male Dummy:**

Bus seat #13

Distance from bus seat back hinge to head CG	x:	-265	y:	-245	z:	1110
Distance from bus seat back hinge to H-point	x:	-270	y:	-150	z:	393
Distance from bus seat back hinge to knee pivot	x:	140	y:	-170	z:	510

**Placement of Right Side, Ballast 6-Yr.-Old Dummy:**

Bus seat #24

Distance from bus seat back hinge to head CG	x:	-330	y:	-145	z:	890
Distance from bus seat back hinge to H-point	x:	-300	y:	-85	z:	465
Distance from bus seat back hinge to knee pivot	x:	-50	y:	-100	z:	406

**Placement of Right Side, Ballast HIII 50<sup>th</sup> Male Dummy:**

Bus seat #24

Distance from bus seat back hinge to head CG	x:	-330	y:	-585	z:	1145
Distance from bus seat back hinge to H-point	x:	-260	y:	-475	z:	451
Distance from bus seat back hinge to knee pivot	x:	140	y:	-495	z:	471

**Placement of Right Side, Ballast HIII 50<sup>th</sup> Male Dummy:**

Bus seat #18

Distance from bus seat back hinge to head CG	x:	-260	y:	-590	z:	1160
Distance from bus seat back hinge to H-point	x:	-276	y:	-450	z:	448
Distance from bus seat back hinge to knee pivot	x:	130	y:	-505	z:	480

**Placement of Right Side, Ballast HIII 50<sup>th</sup> Male Dummy:**

Bus seat #18

Distance from bus seat back hinge to head CG	x:	-348	y:	-70	z:	1160
Distance from bus seat back hinge to H-point	x:	-285	y:	40	z:	470
Distance from bus seat back hinge to knee pivot	x:	115	y:	5	z:	498

Figure 6 Camera Positions

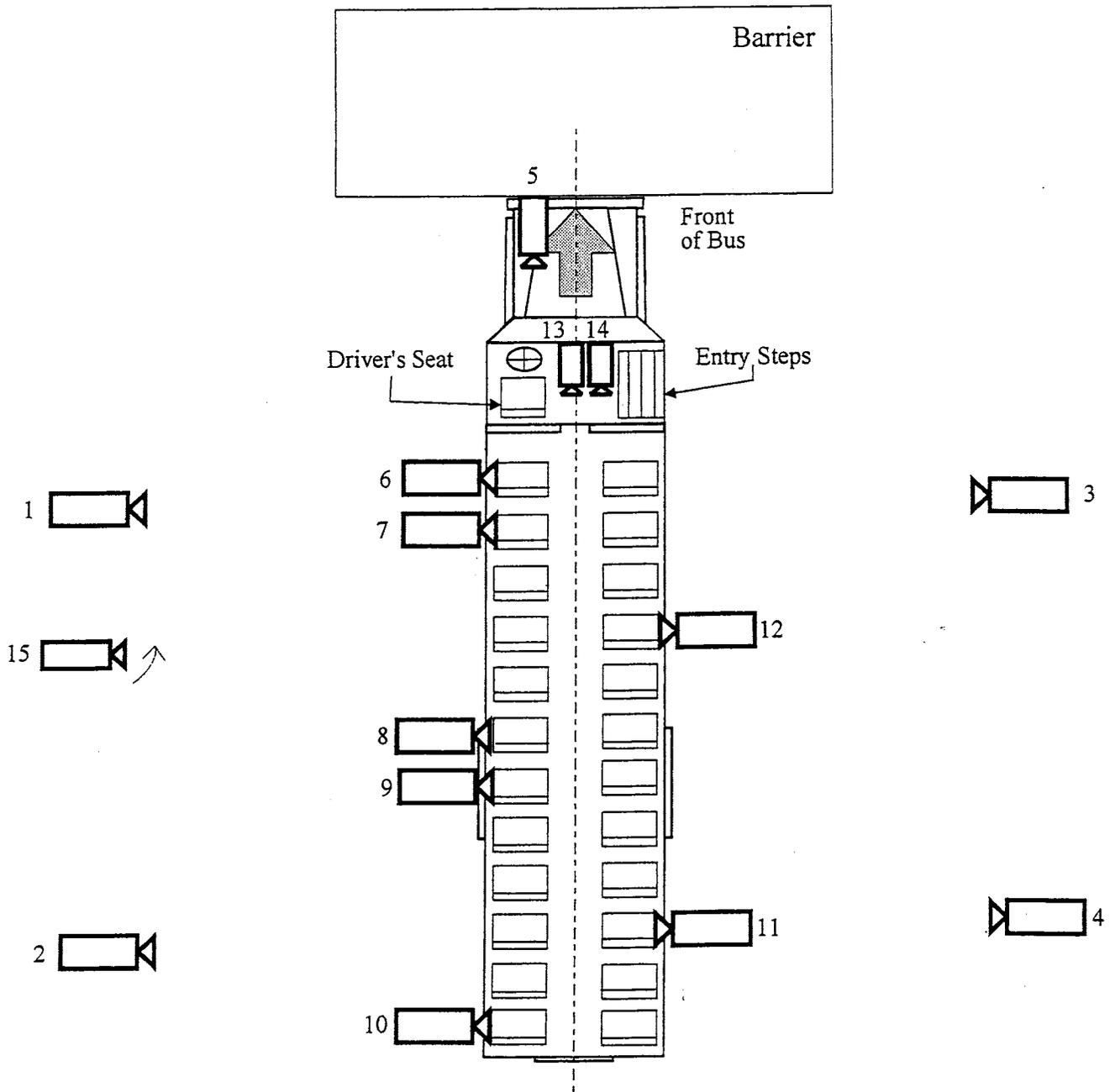


Table 8 Motion Picture Camera Locations

Vehicle year/make/model/body style: 1997/Thomas Built/Bus

Test number: 990421-1

Camera Number	View	Camera Positions <sup>1</sup>			Camera Angle <sup>2</sup>	Film Plane to Head Target	Camera Lens	Film Speed
		X	Y	Z				
1	Left front	7' 4"	30' 0"	4' 10"	0°	NA	10 mm	1005 frames/s
2	Left rear	26' 0"	28' 10"	5' 0"	0°	NA	13 mm	990 frames/s
3	Right front	9' 0"	-29' 0"	5' 0"	0°	NA	13 mm	1012 frames/s
4	Right rear	27' 3"	-34' 0"	5' 0"	0°	NA	13 mm	753 frames/s
5	Front roof line	-0' 14"	22' 0"	11' 8"	0°	NA	Zoom	508 frames/s
6	Right #24 seat	10' 6"	4' 4"	6' 4"	0°	NA	8 mm	968 frames/s
7	Right #23 seat	12' 10"	4' 4"	6' 4"	0°	NA	8 mm	992 frames/s
8	Right #19 seat	22' 3"	4' 4"	6' 4"	0°	NA	8.5 mm	455 frames/s
9	Right #18 seat	24' 2"	4' 4"	6' 4"	0°	NA	8 mm	708 frames/s
10	Right #13 seat	34' 8"	4' 4"	6' 3"	0°	NA	8 mm	828 frames/s
11	Left #9 seat	29' 0"	-4' 4"	6' 3"	0°	NA	8 mm	1005 frames/s
12	Left #4 seat	17' 7"	-4' 4"	6' 3"	0°	NA	8 mm	750 frames/s
13	Front (Frontal area)	7' 0"	-3' 0"	8' 9"	0°	NA	8 mm	555 frames/s
14	Front (Rear area)	7' 0"	0' 6"	8' 9"	0°	NA	13 mm	520 frames/s
15	Real-time panning	NA	NA	NA	NA	NA	16 mm	24 frames/s

<sup>1</sup> +X: Film plane forward of barrier face

+Y: Film plane to left of monorail centerline

+Z: Film plane above ground level

<sup>2</sup> +Angle: Film plane angled upward from horizontal plane

Appendix A

Photographs



**Figure A-1 Pre-Test Front View**



**Figure A-2 Post-Test Front View**



Figure A-3 Pre-Test Left Front Three-Quarter View



Figure A-4 Post-Test Left Front Three-Quarter View



Figure A-5 Pre-Test Left Side View



Figure A-6 Post-Test Left Side View



Figure A-7 Pre-Test Rear View



Figure A-8 Post-Test Rear View



Figure A-9 Pre-Test Right Side View



Figure A-10 Post-Test Right Side View



**Figure A-11 Pre-Test Right Front Three-Quarter View**



**Figure A-12 Post-Test Right Front Three-Quarter View**

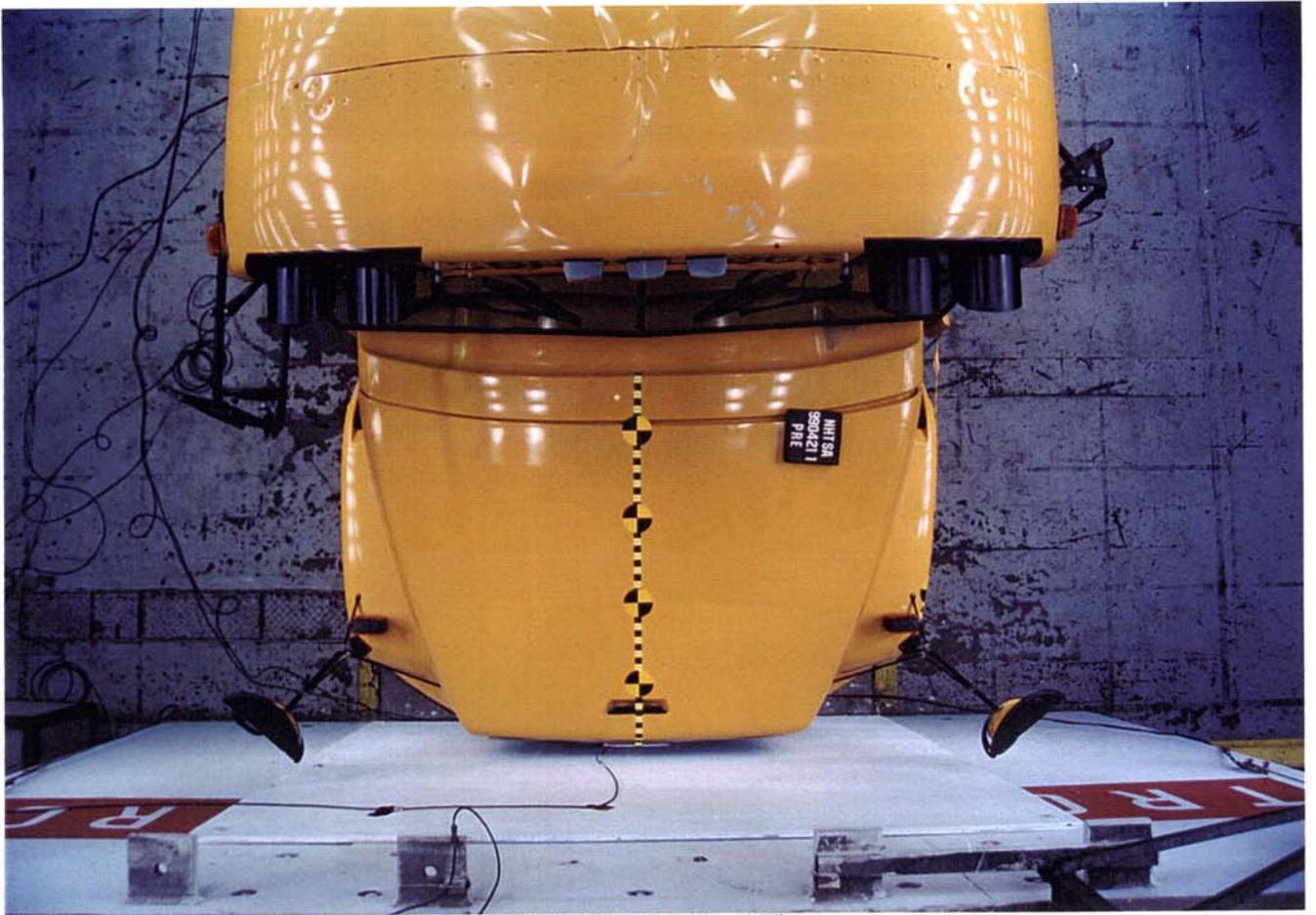


Figure A-13 Pre-Test Overhead View

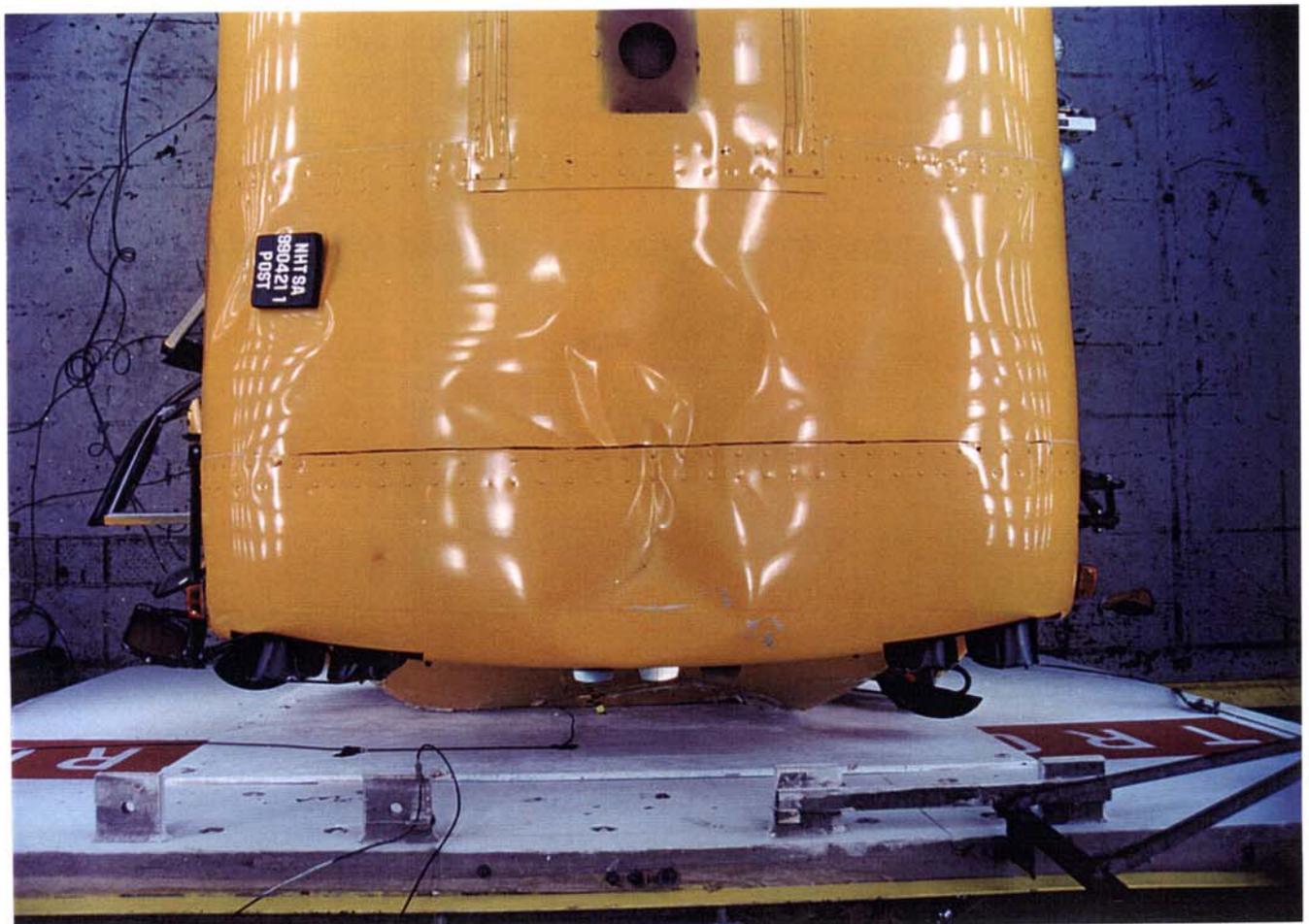


Figure A-14 Post-Test Overhead View

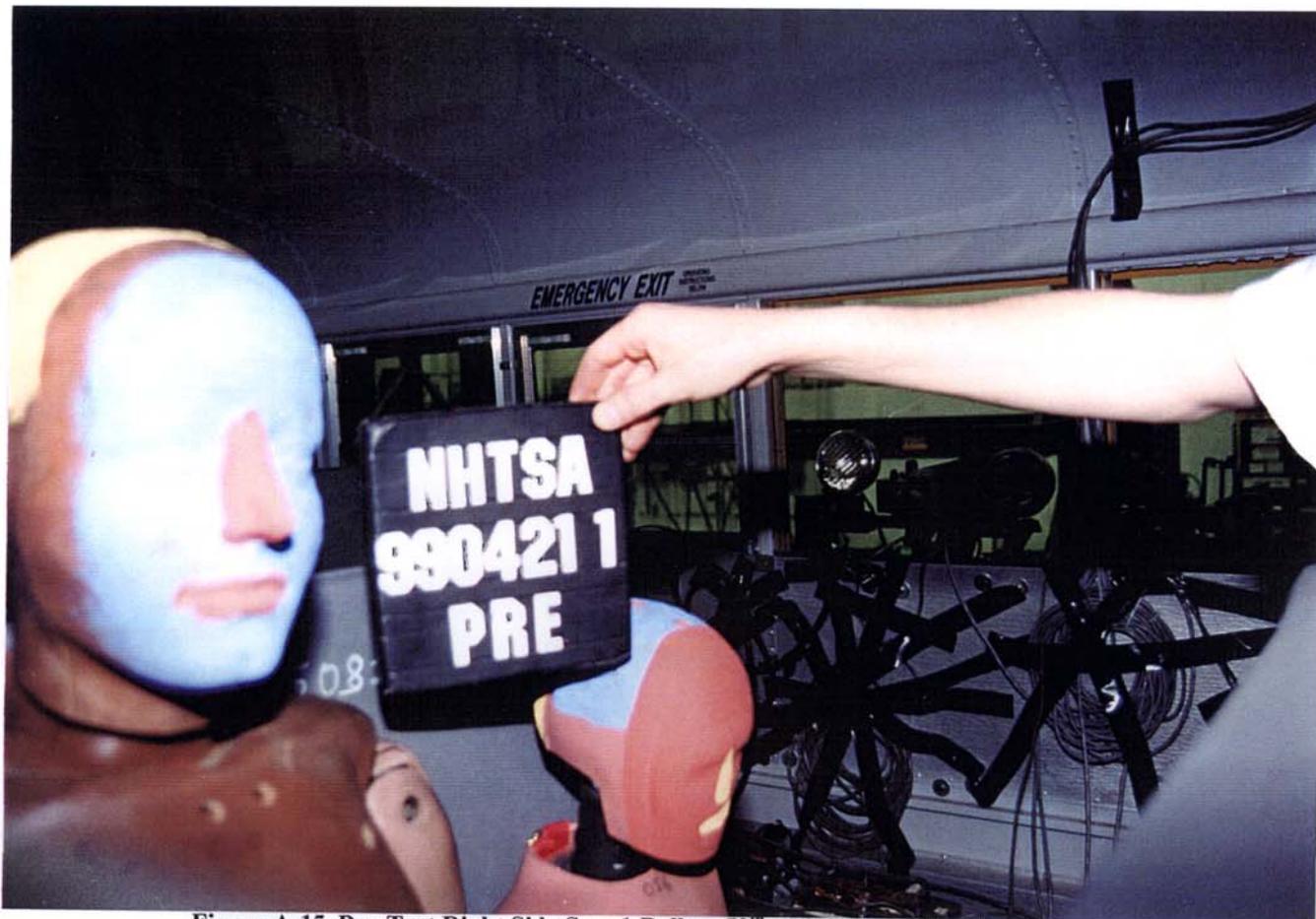


Figure A-15 Pre-Test Right Side Seat 1 Ballast 50<sup>th</sup> and 6 Year Old - View 1

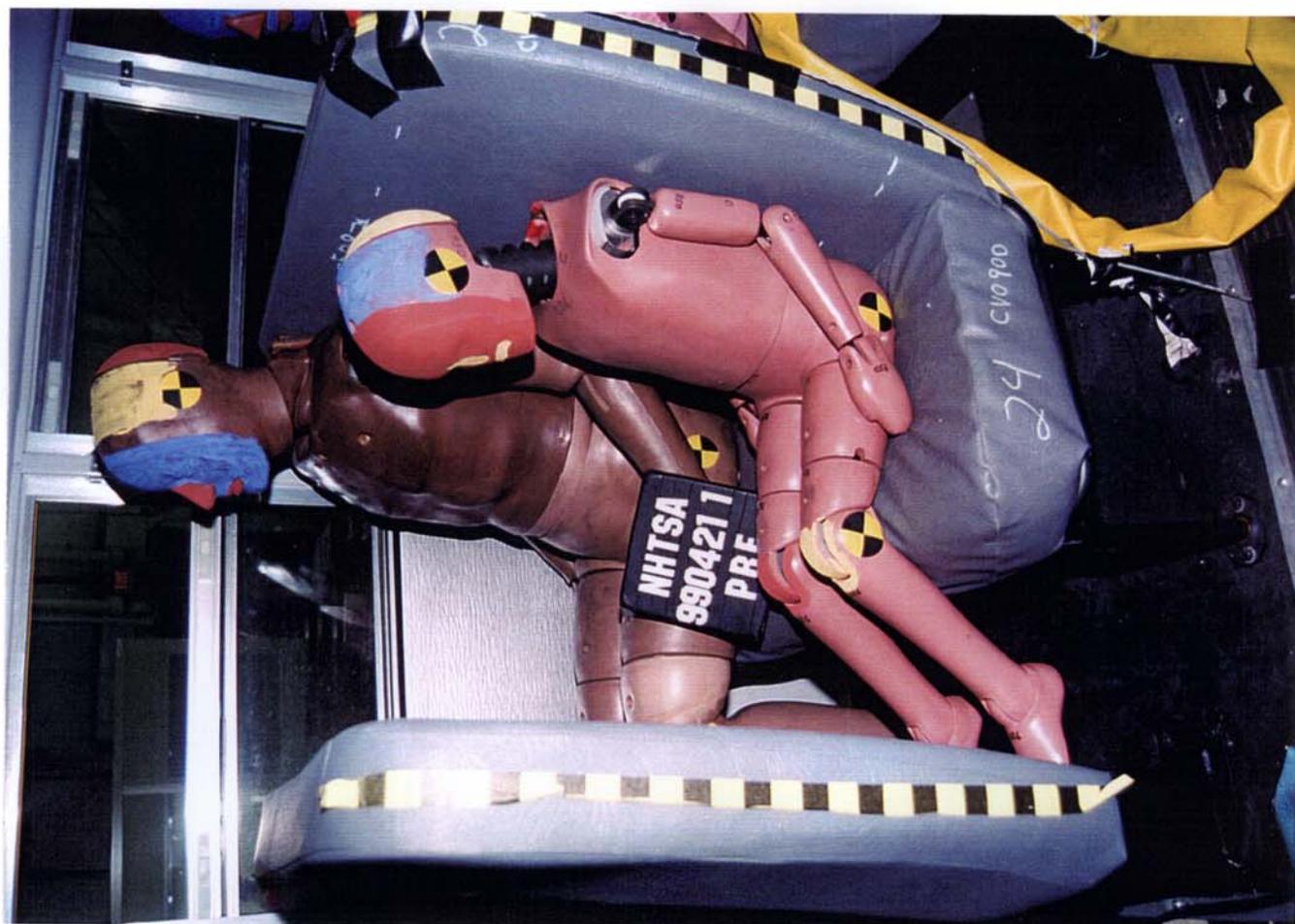


Figure A-16 Pre-Test Right Side Seat 1 Ballast 50<sup>th</sup> and 6 Year Old - View 2



Figure A-17 Pre-Test Right Side Seat 1 Ballast 50<sup>th</sup> and 6 Year Old - View 3



Figure A-18 Pre-Test Right Side Seat 2 Instrumented 50<sup>th</sup> - View 1

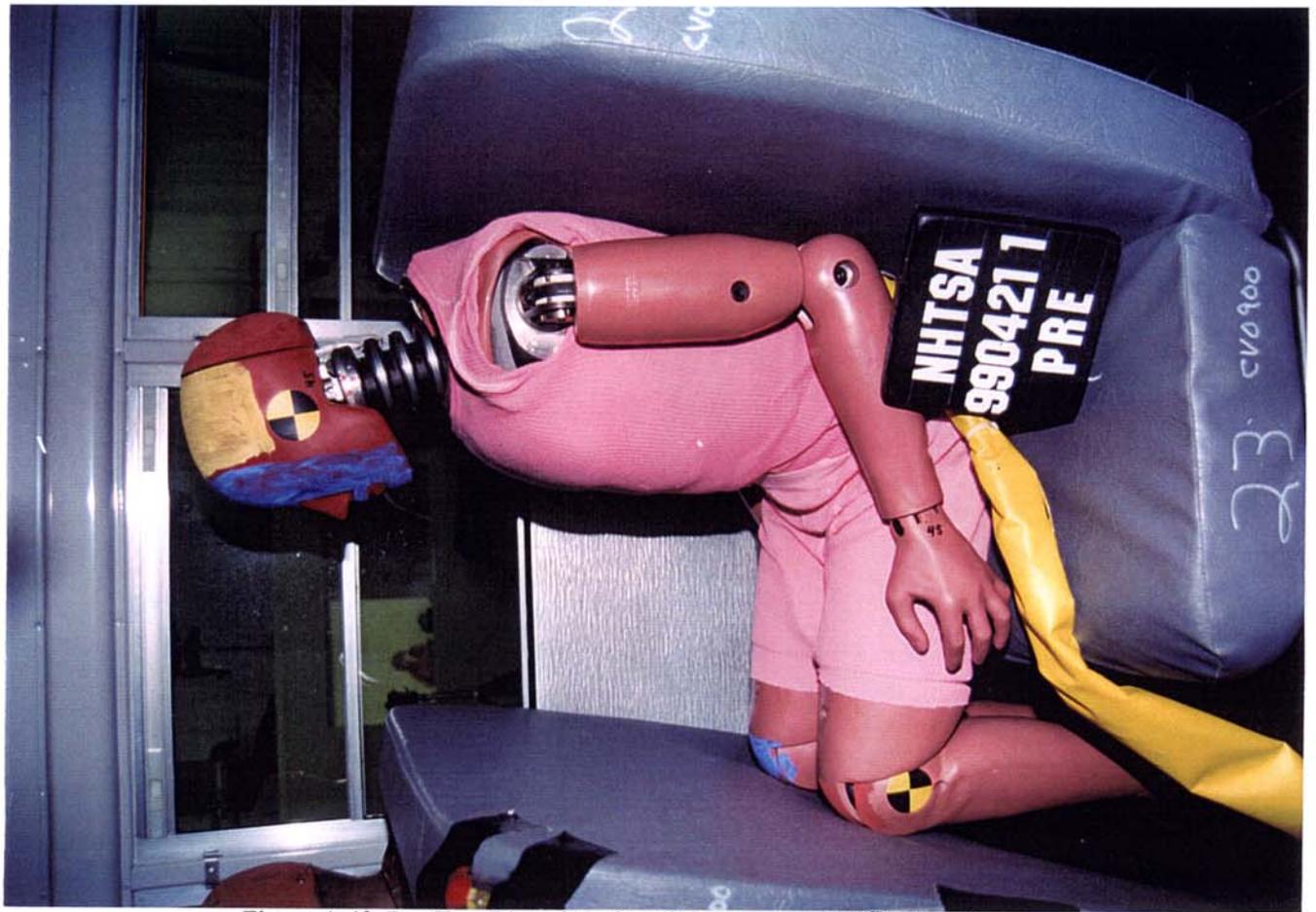


Figure A-19 Pre-Test Right Side Seat 2 Instrumented 50<sup>th</sup> - View 2



Figure A-20 Pre-Test Right Side Seat 2 Instrumented 50<sup>th</sup> - View 3



Figure A-21 Pre-Test Left Side Seat 4 Instrumented 6 Year Old - View 1



Figure A-22 Pre-Test Left Side Seat 4 Instrumented 6 Year Old - View 2



Figure A-23 Pre-Test Left Side Seat 4 Instrumented 6 Year Old - View 3



Figure A-24 Pre-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 1



Figure A-25 Pre-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 2



Figure A-26 Pre-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 3



Figure A-27 Pre-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 1



Figure A-28 Pre-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 2



Figure A-29 Pre-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 3



Figure A-30 Pre-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 1

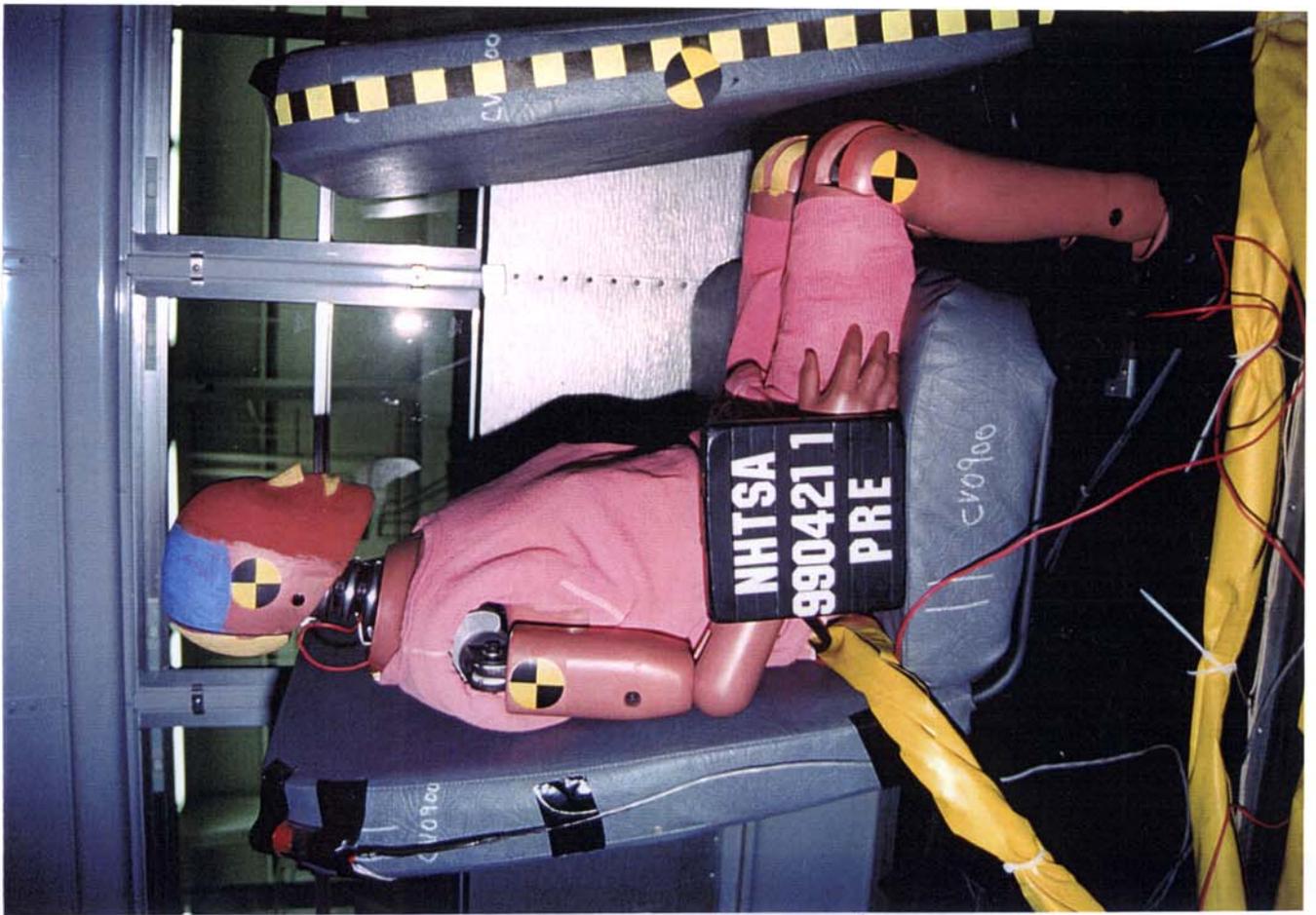


Figure A-31 Pre-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 2



Figure A-32 Pre-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 3



Figure A-33 Pre-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 1

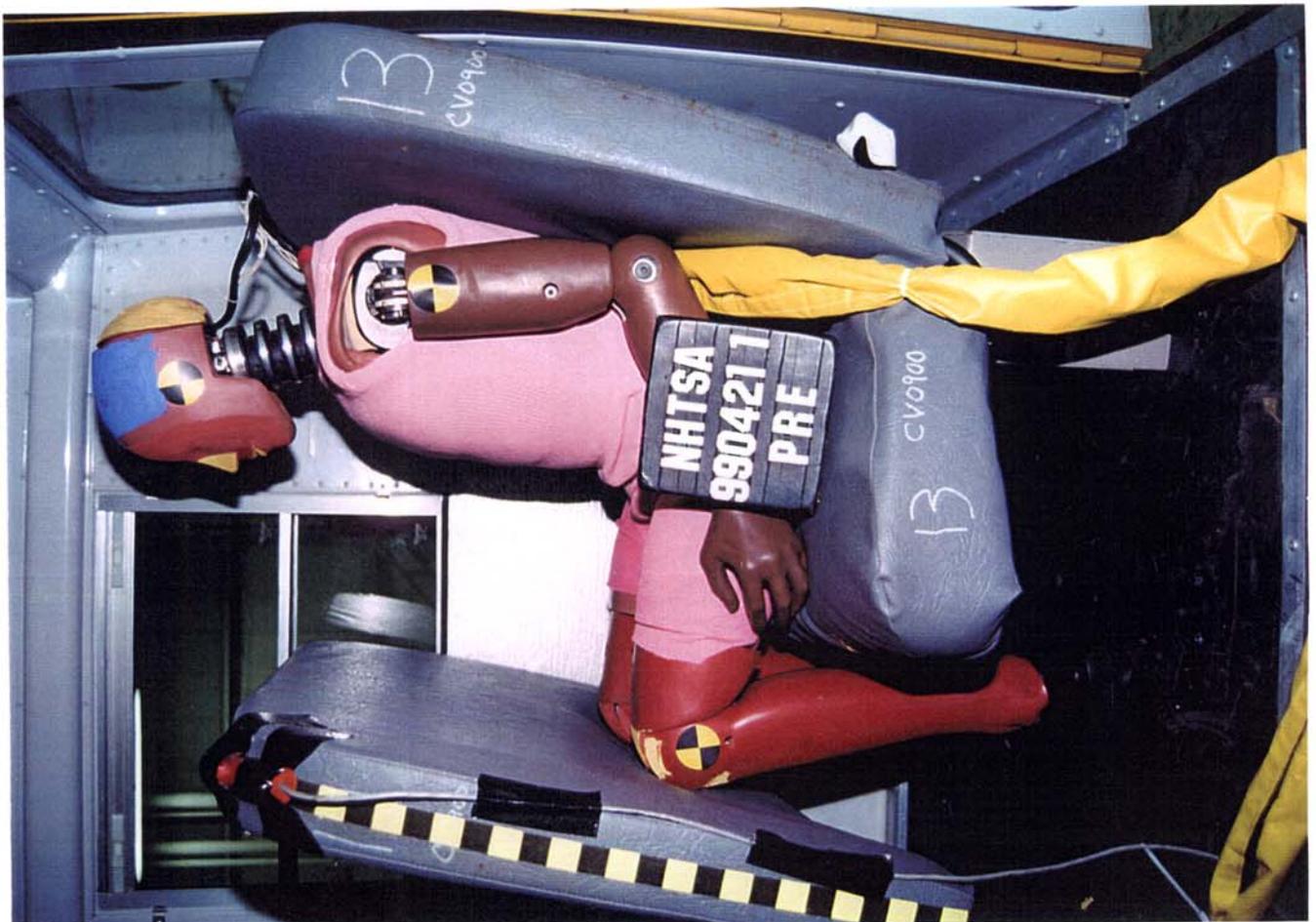


Figure A-34 Pre-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 2



Figure A-35 Pre-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 3

Intentionally Left Blank

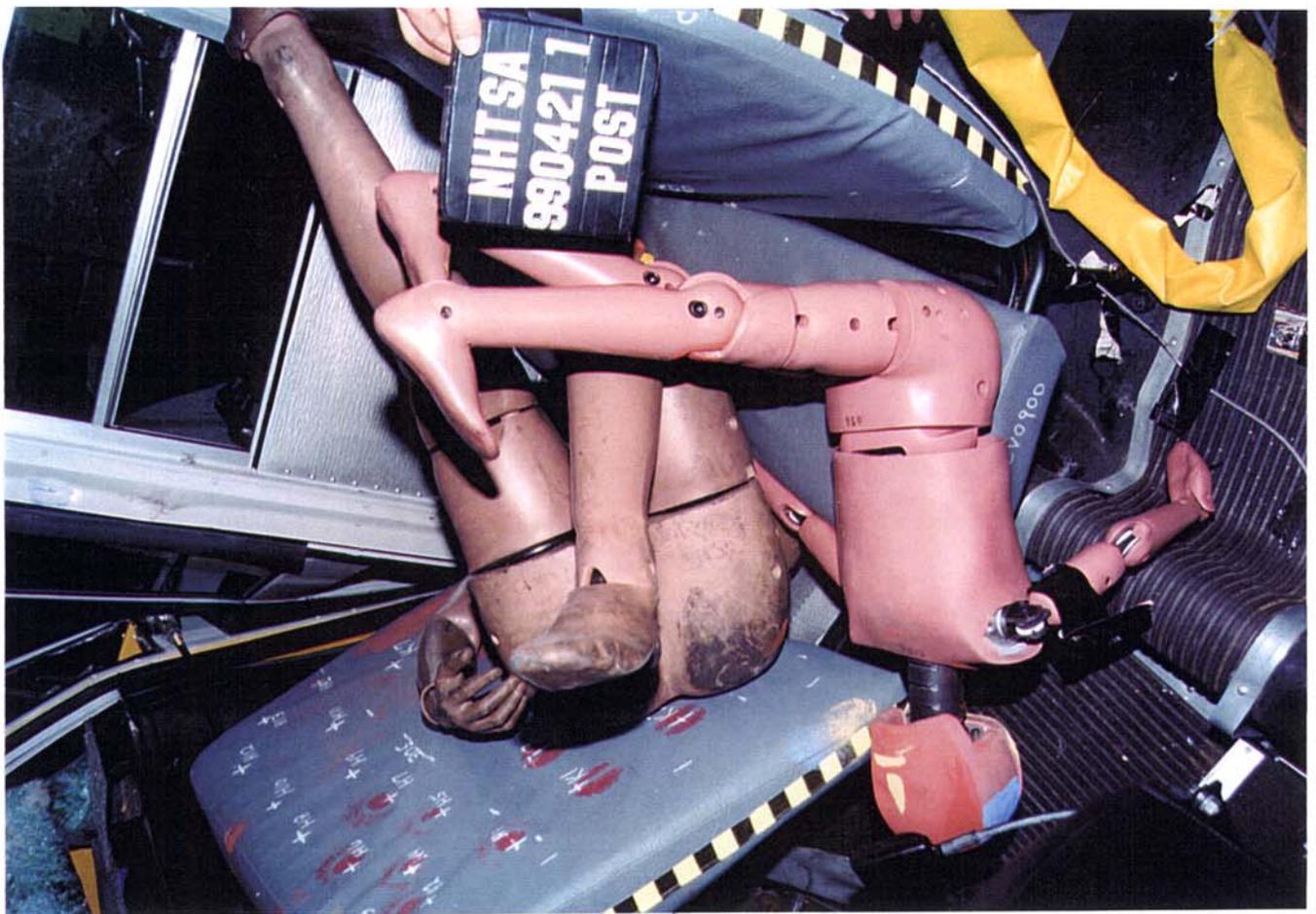


Figure A-36 Post-Test Right Side Seat 1 50<sup>th</sup> and 6 Year Old Ballast - View 1

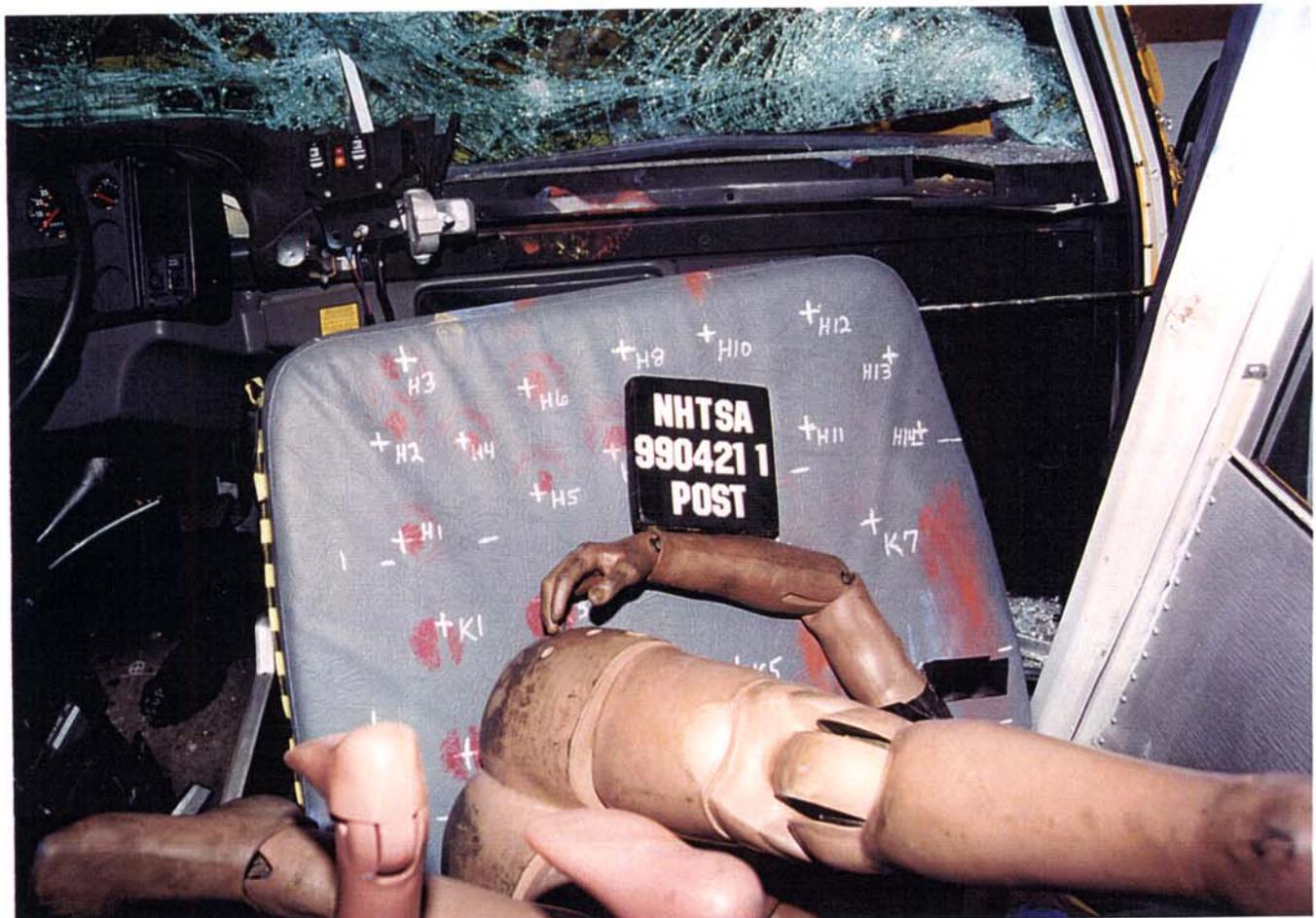


Figure A-37 Post-Test Right Side Seat 1 50<sup>th</sup> and 6 Year Old Ballast - View 2



Figure A-38 Post-Test Right Side Seat 1 50<sup>th</sup> and 6 Year Old Ballast - View 3



Figure A-39 Post-Test Right Side Seat 1 50<sup>th</sup> and 6 Year Old Ballast - View 4



Figure A-40 Post-Test Right Side Seat 1 50<sup>th</sup> and 6 Year Old Ballast - View 5



Figure A-41 Post-Test Right Side Seat 2 Instrumented 50<sup>th</sup> - View 1

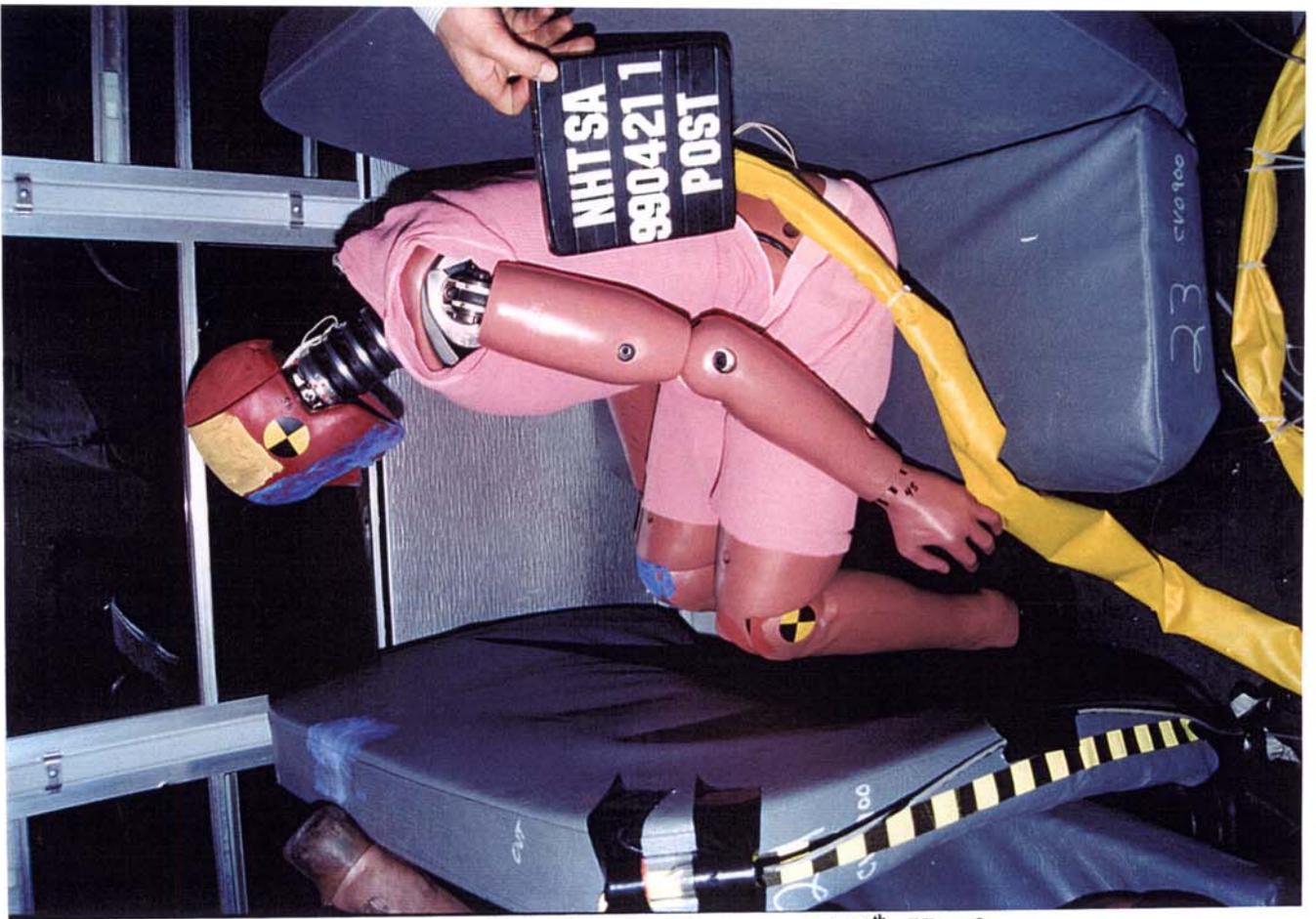


Figure A-42 Post-Test Right Side Seat 2 Instrumented 50<sup>th</sup> - View 2

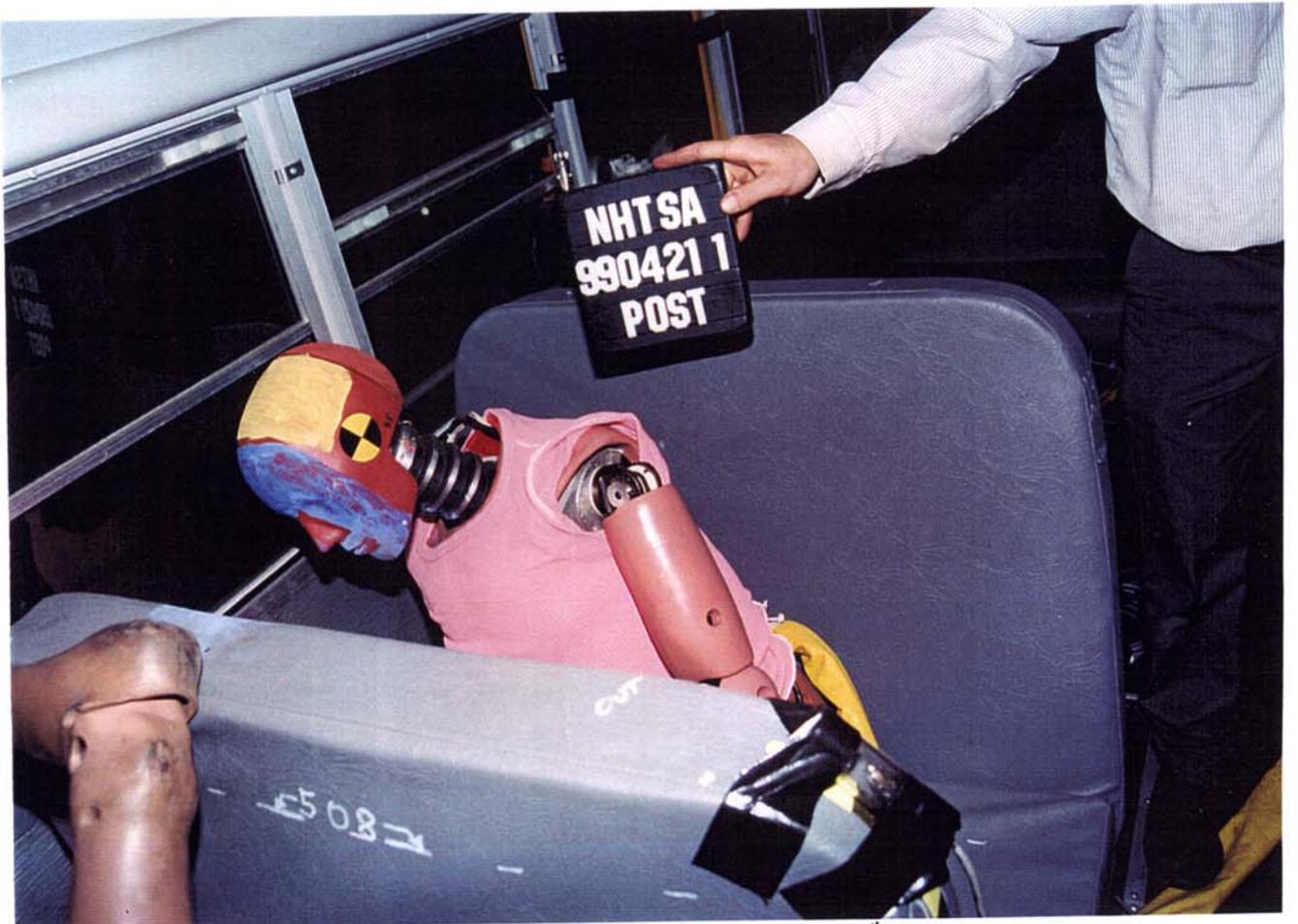


Figure A-43 Post-Test Right Side Seat 2 Instrumented 50<sup>th</sup> - View 3

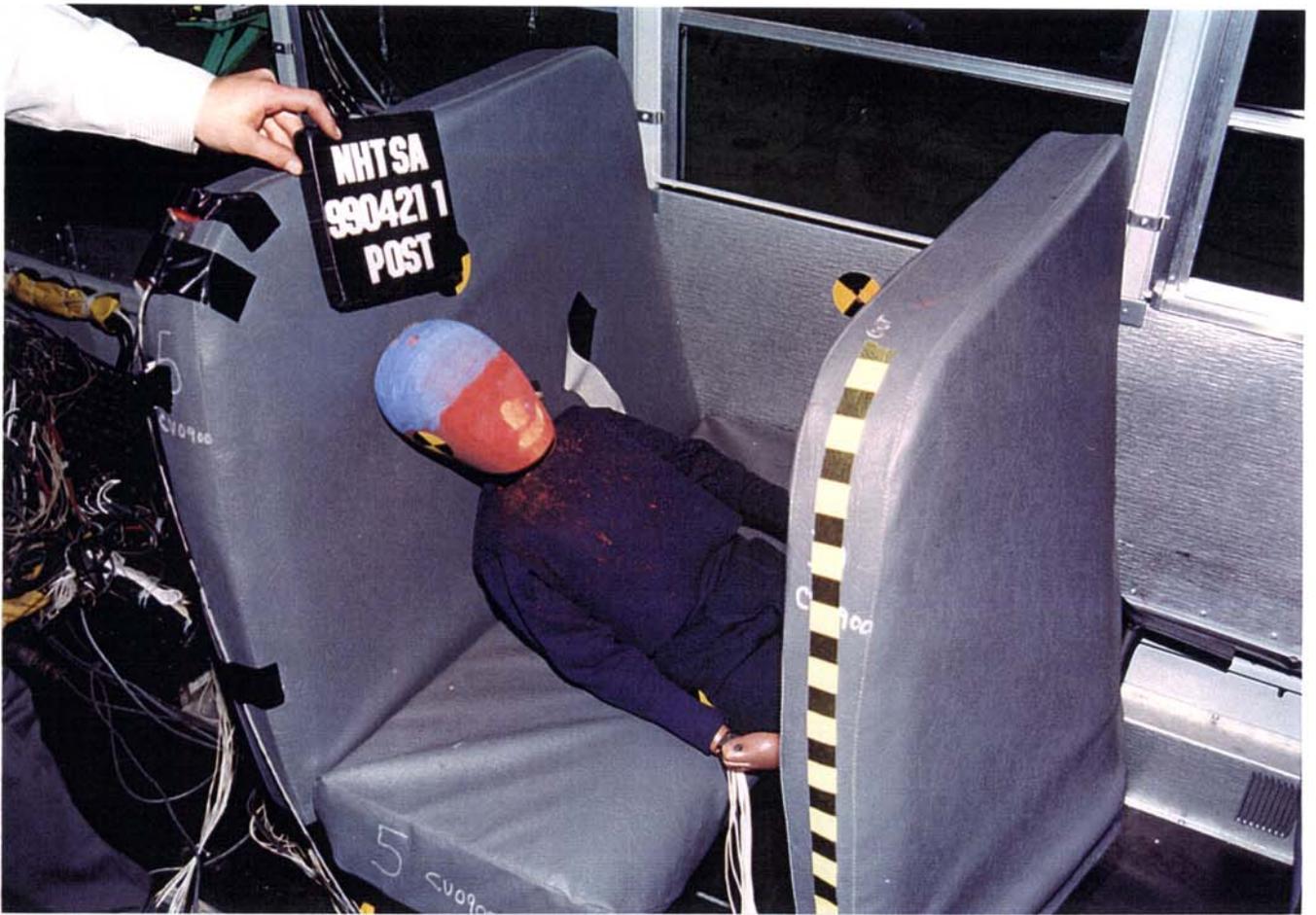


Figure A-44 Post-Test Left Side Seat 4 Instrumented 6 Year Old - View 1

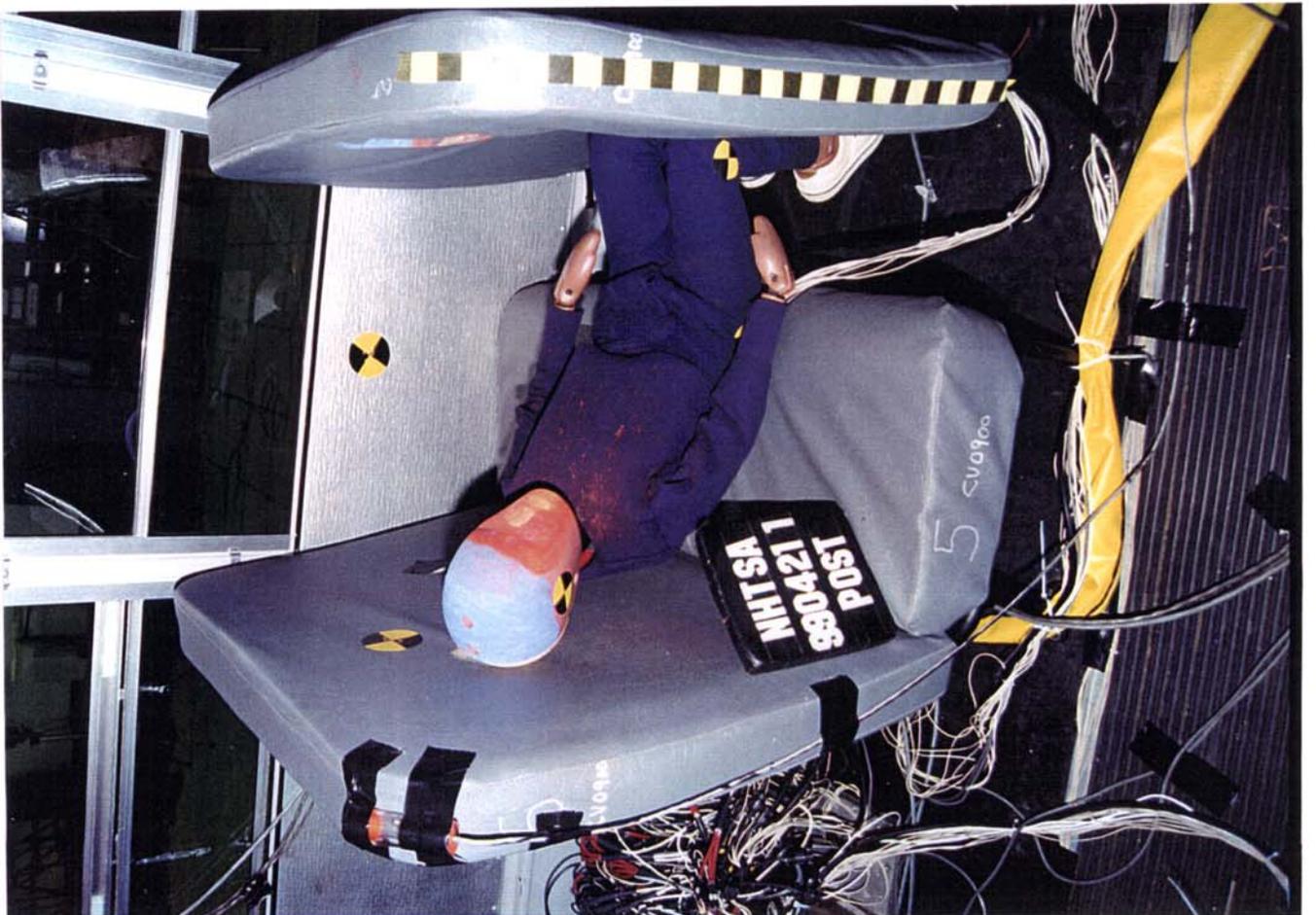


Figure A-45 Post-Test Left Side Seat 4 Instrumented 6 Year Old - View 2



Figure A-46 Post-Test Left Side Seat 4 Instrumented 6 Year Old - View 3

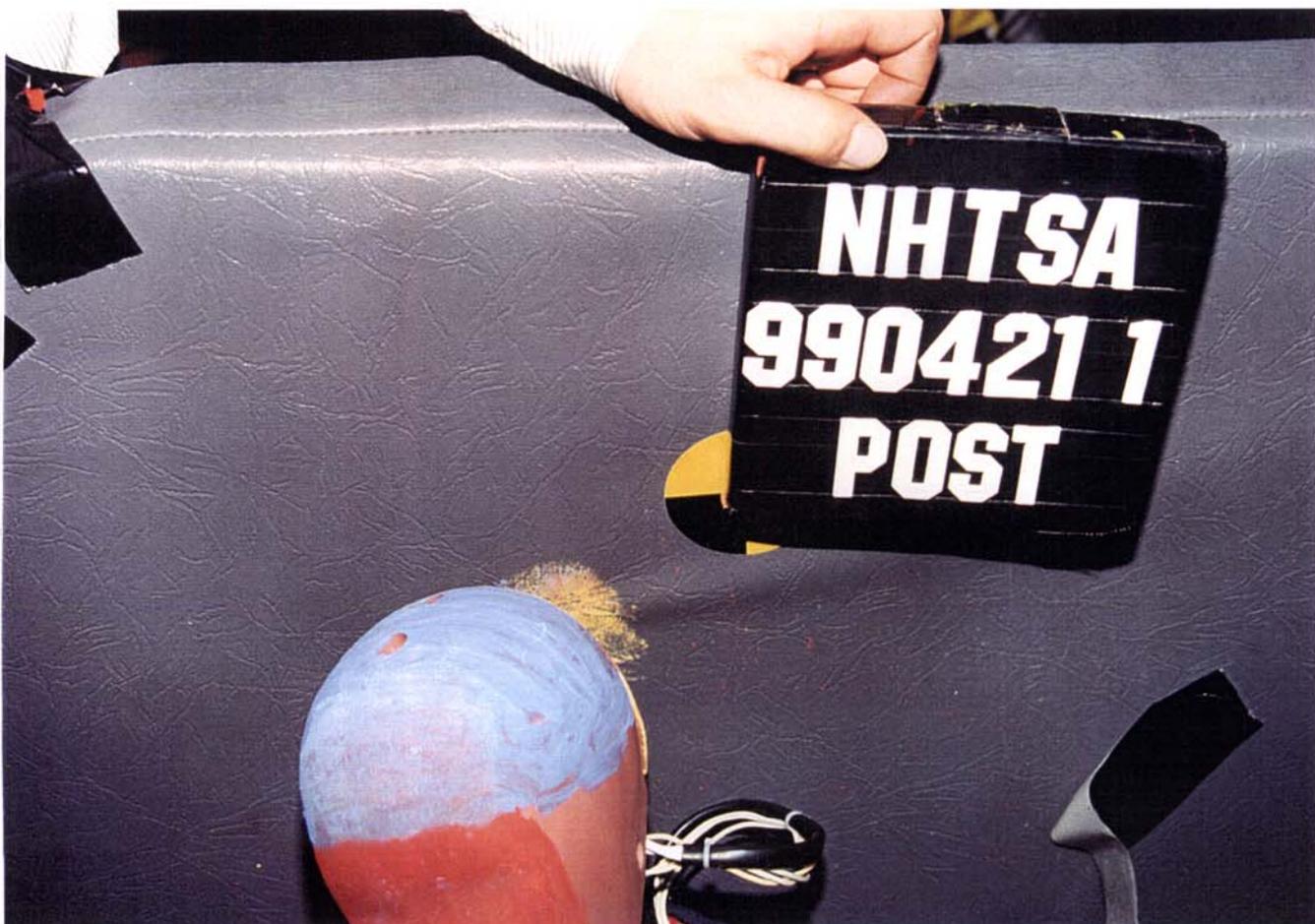


Figure A-47 Post-Test Left Side Seat 4 Instrumented 6 Year Old - View 4



Figure A-48 Post-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 1

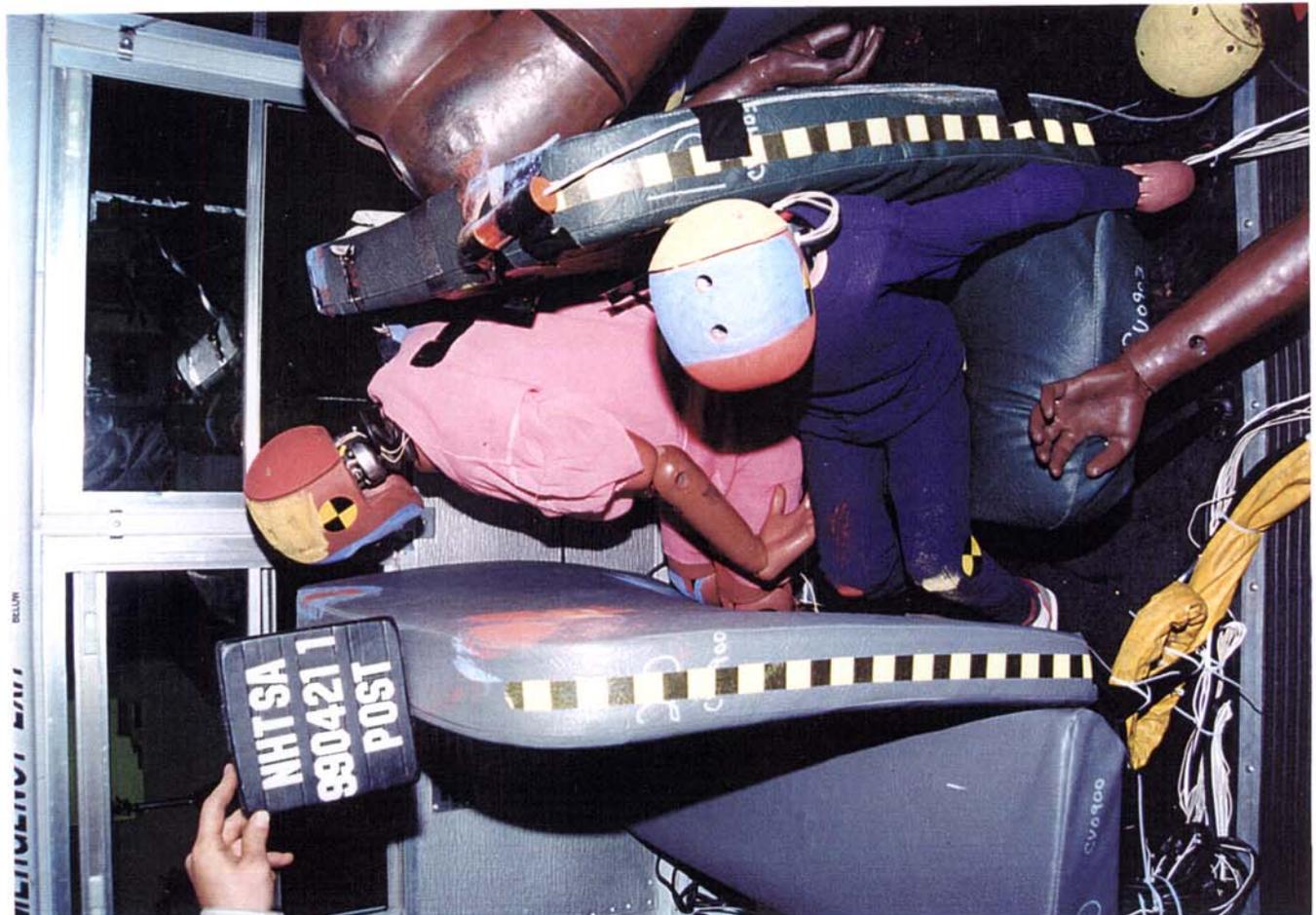


Figure A-49 Post-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 2



Figure A-50 Post-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 3



Figure A-51 Post-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 4



Figure A-52 Post-Test Right Side Seat 6 Instrumented 5<sup>th</sup> and 6 Year Old - View 5



Figure A-53 Post-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 1



Figure A-54 Post-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 2



Figure A-55 Post-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 3

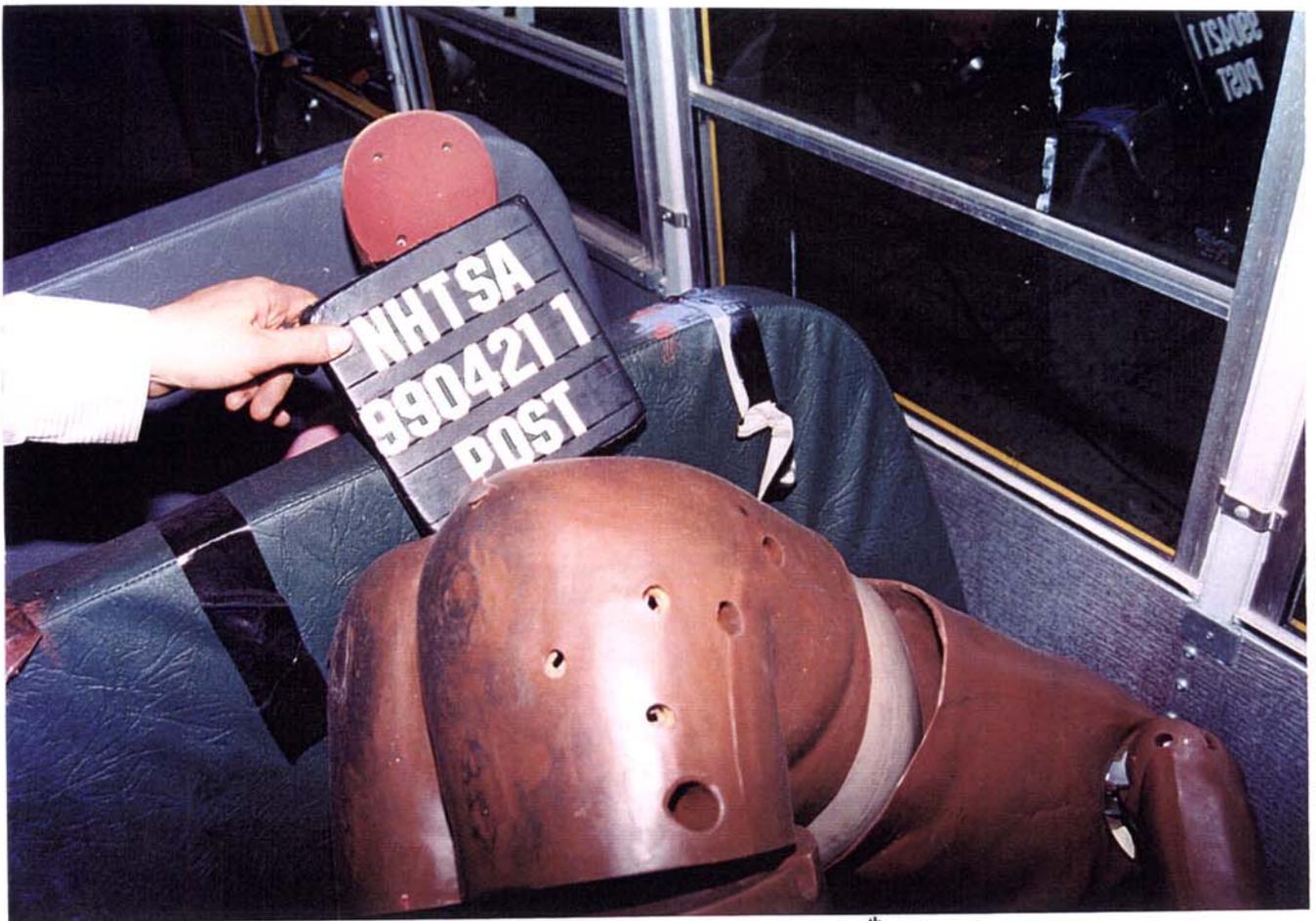


Figure A-56 Post-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 4

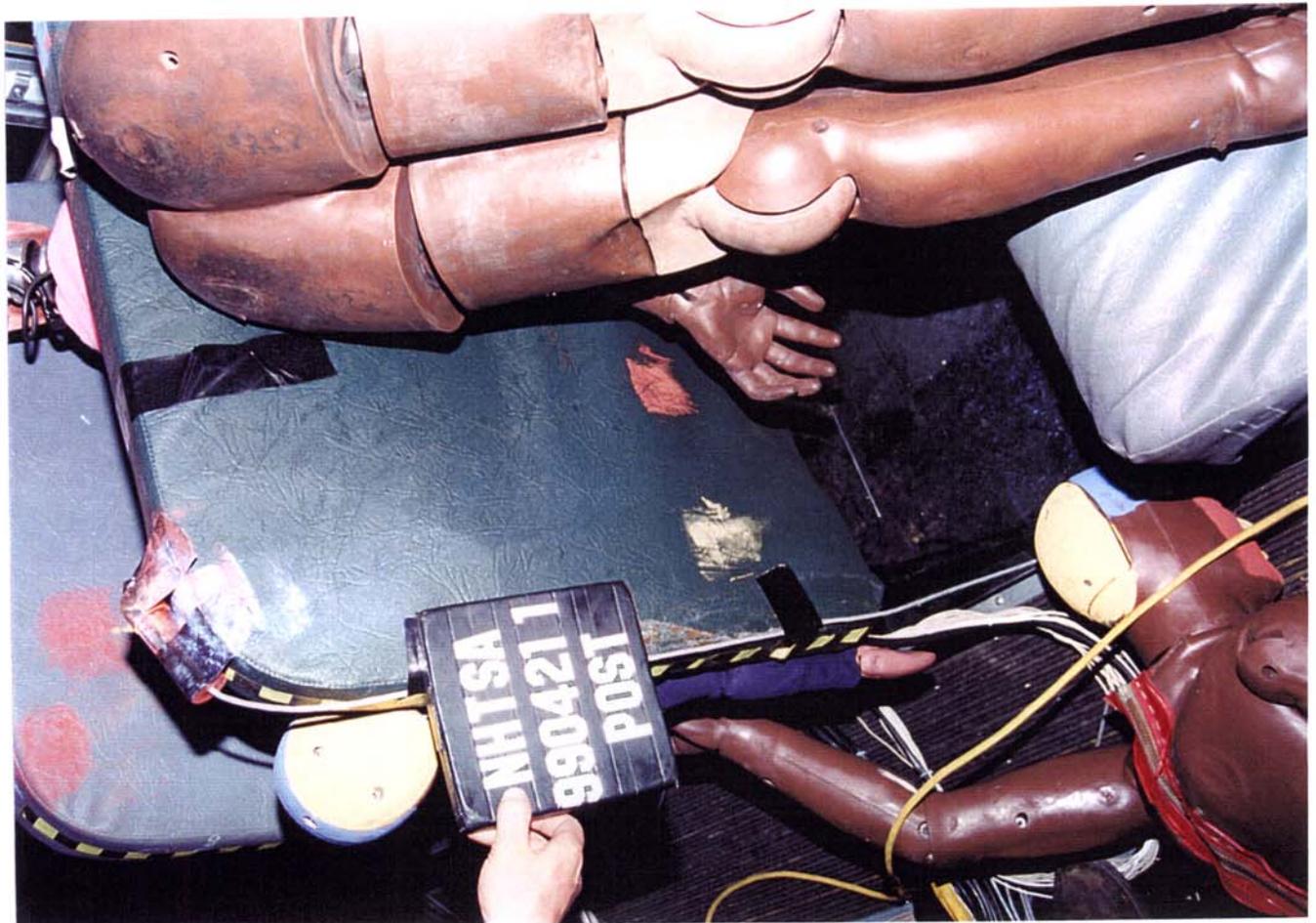


Figure A-57 Post-Test Right Side Seat 7 Two Ballast 50<sup>th</sup> - View 5



Figure A-58 Post-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 1



Figure A-59 Post-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 2



Figure A-60 Post-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 3

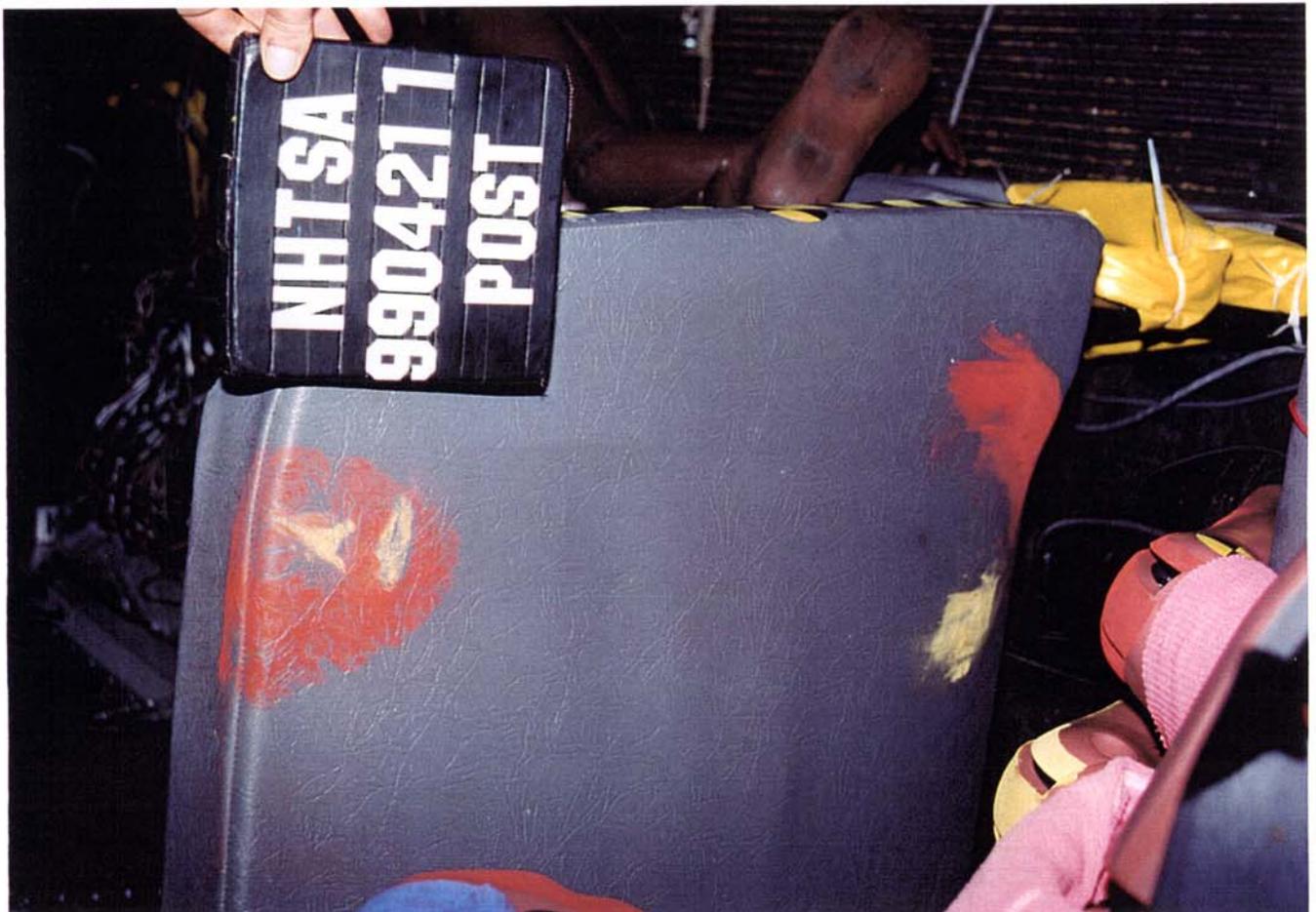


Figure A-61 Post-Test Left Side Seat 10 Instrumented 5<sup>th</sup> - View 4



Figure A-62 Post-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 1



Figure A-63 Post-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 2

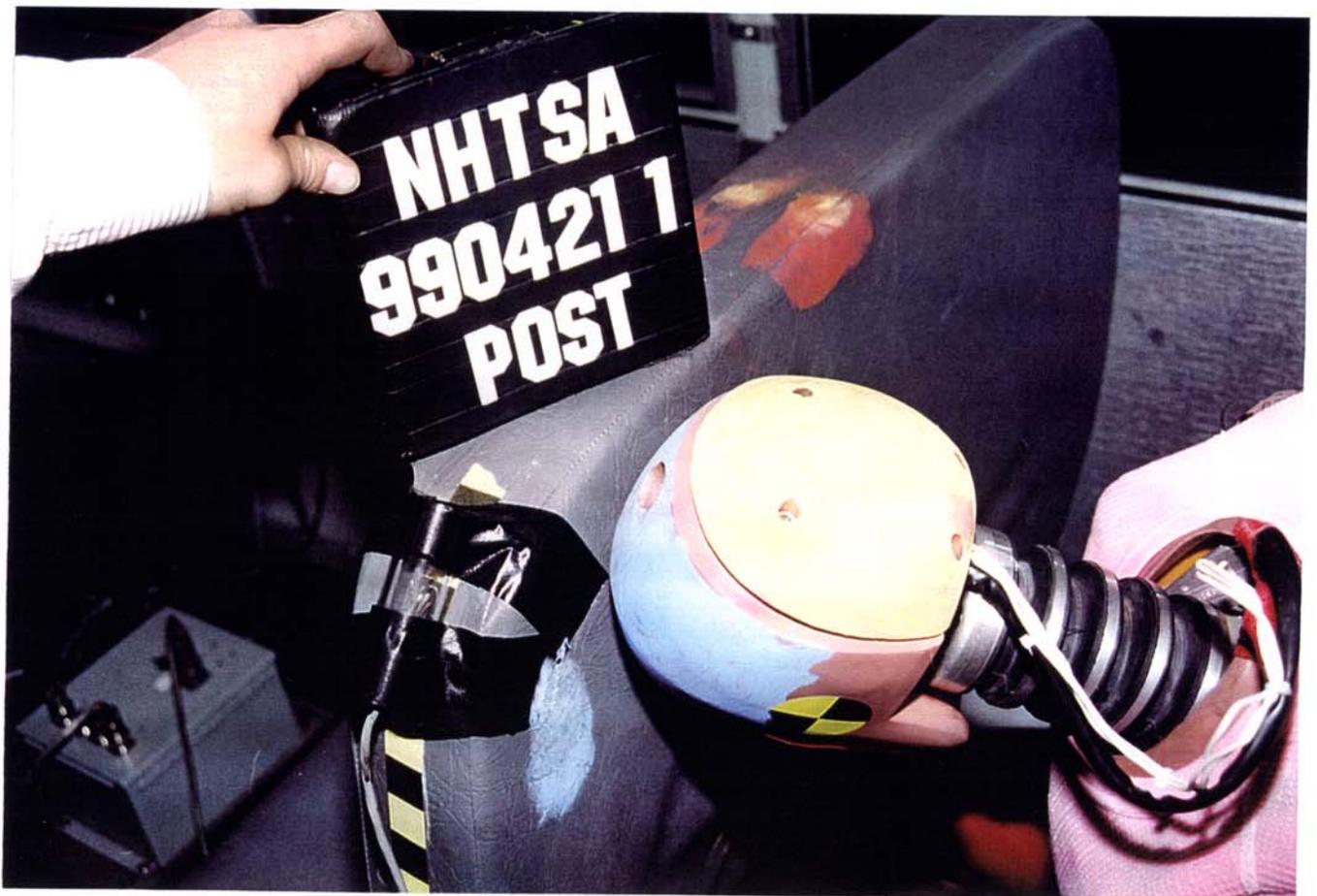


Figure A-64 Post-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 3



Figure A-65 Post-Test Right Side Seat 12 Instrumented 50<sup>th</sup> - View 4

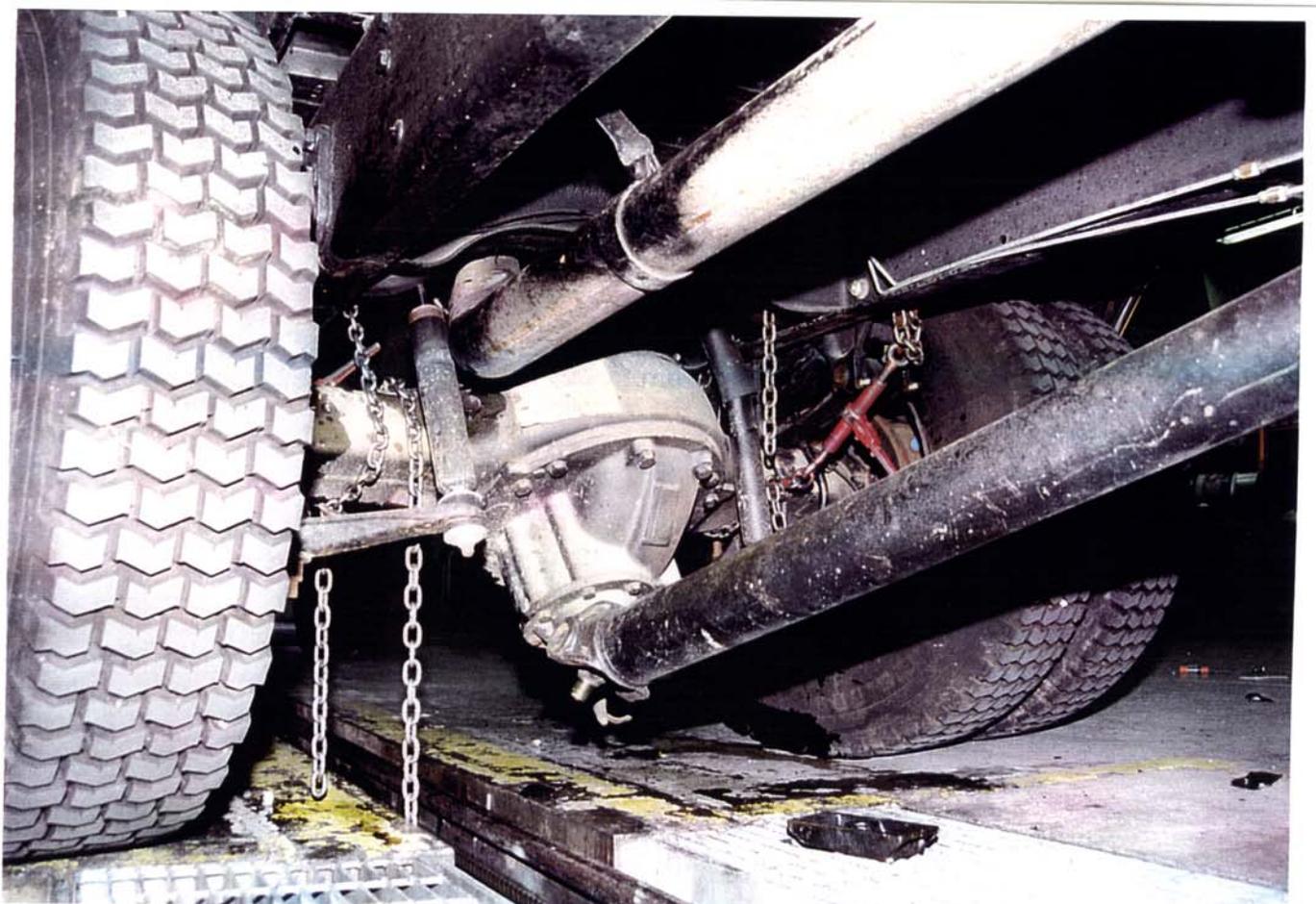


Figure A-66 Post-Test Miscellaneous Damage - View 1

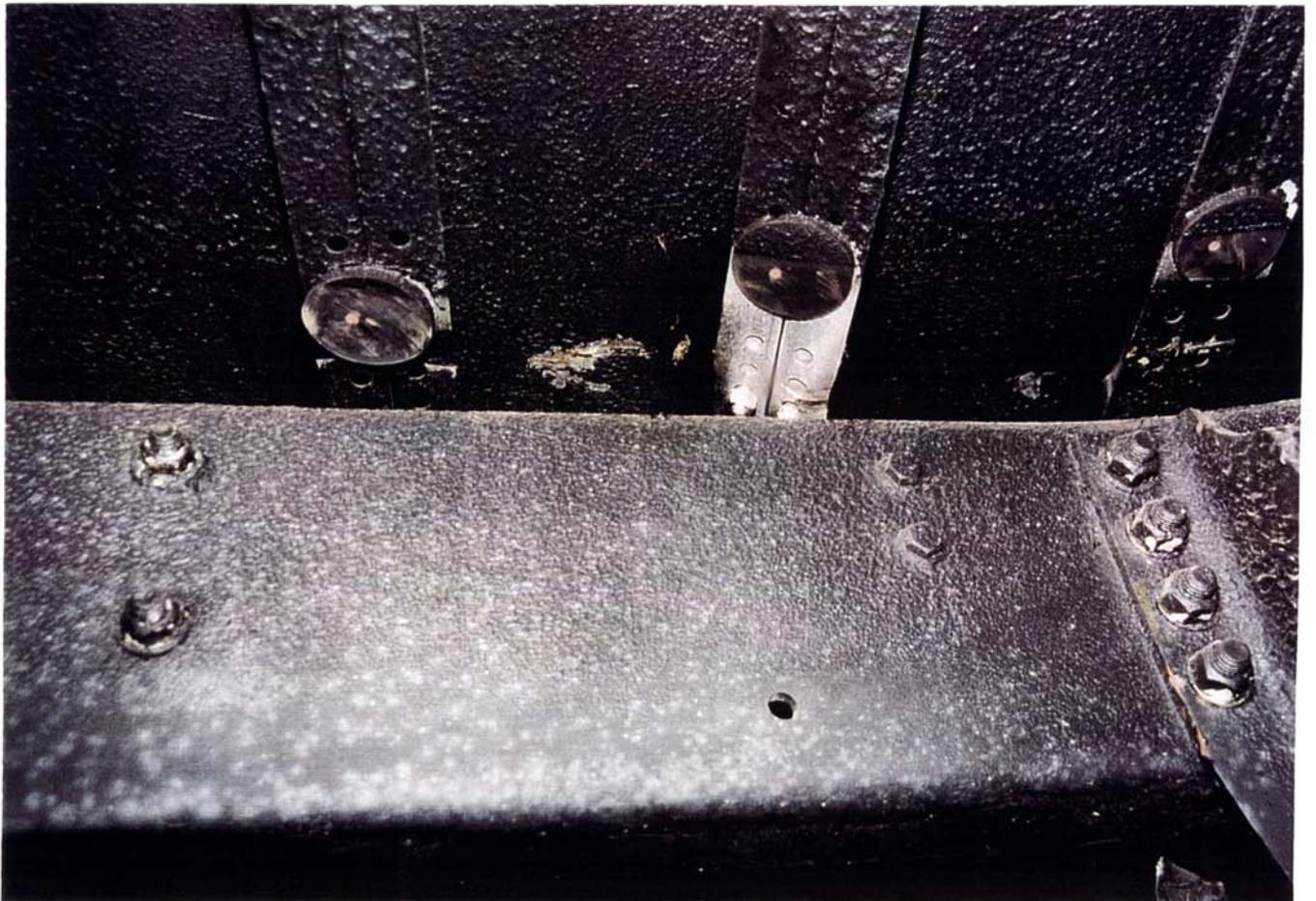


Figure A-67 Post-Test Miscellaneous Damage - View 2

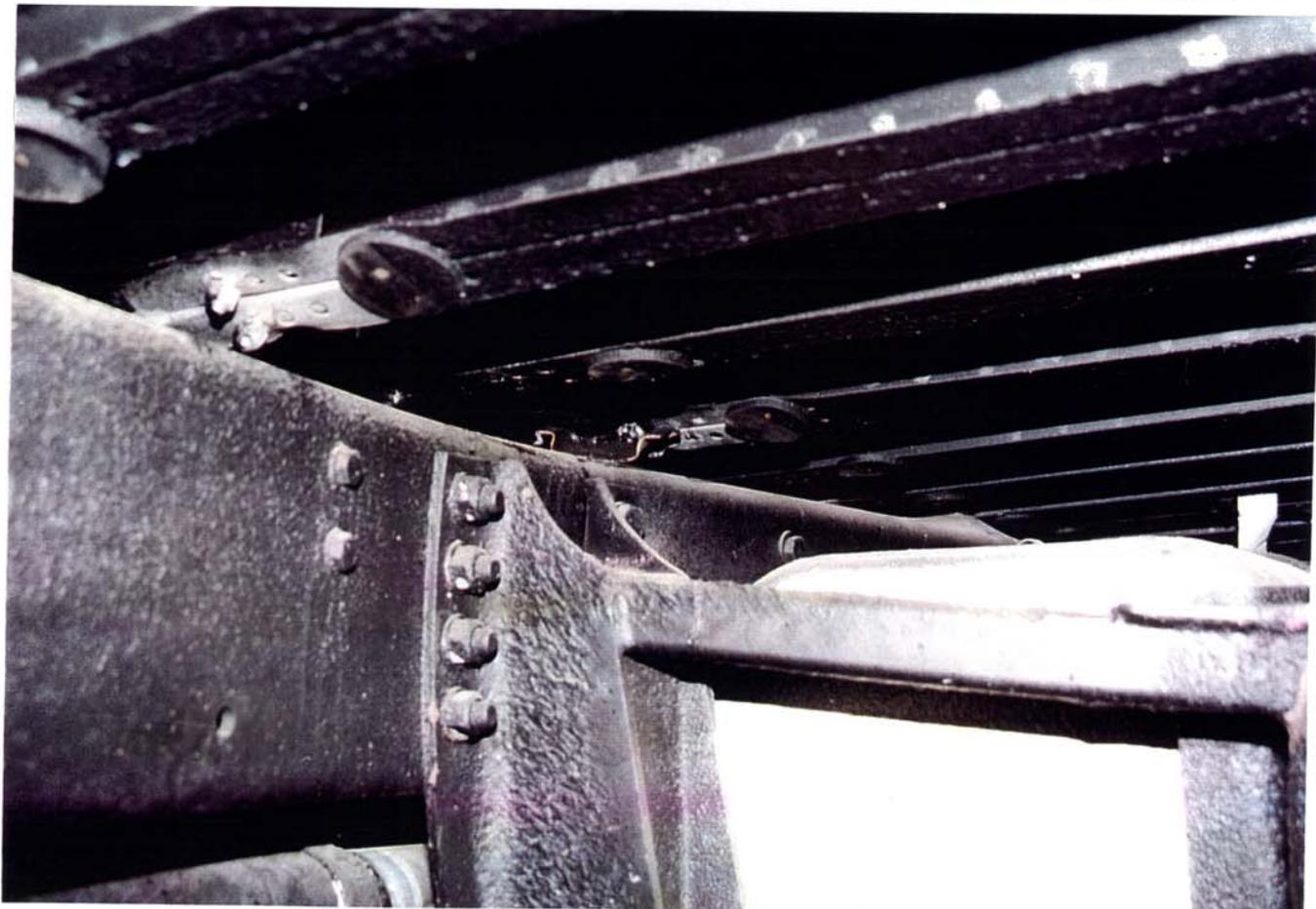


Figure A-68 Post-Test Miscellaneous Damage - View 3



Figure A-69 Post-Test Miscellaneous Damage - View 4



Figure A-70 Post-Test Miscellaneous Damage - View 5

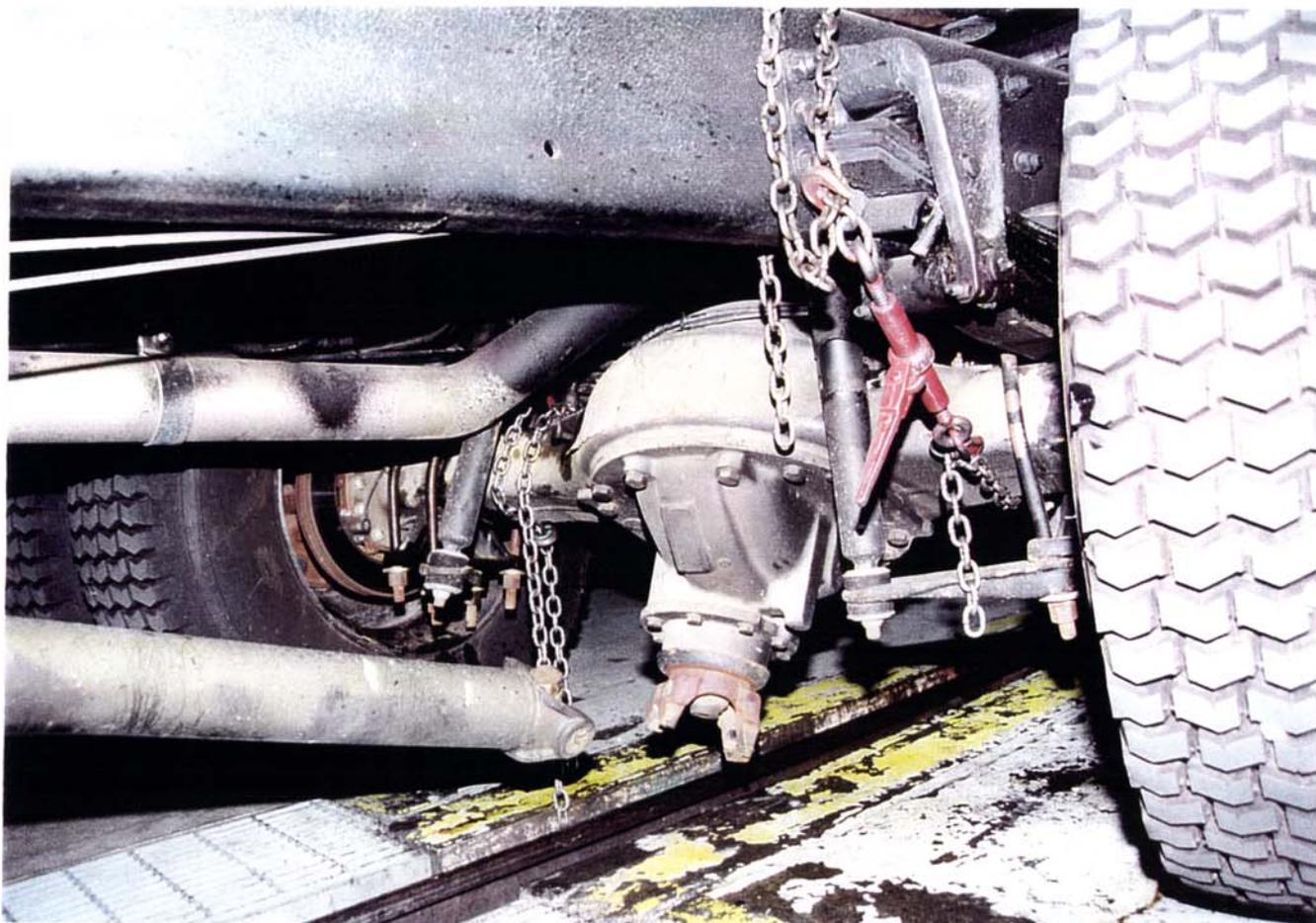


Figure A-71 Post-Test Miscellaneous Damage - View 6

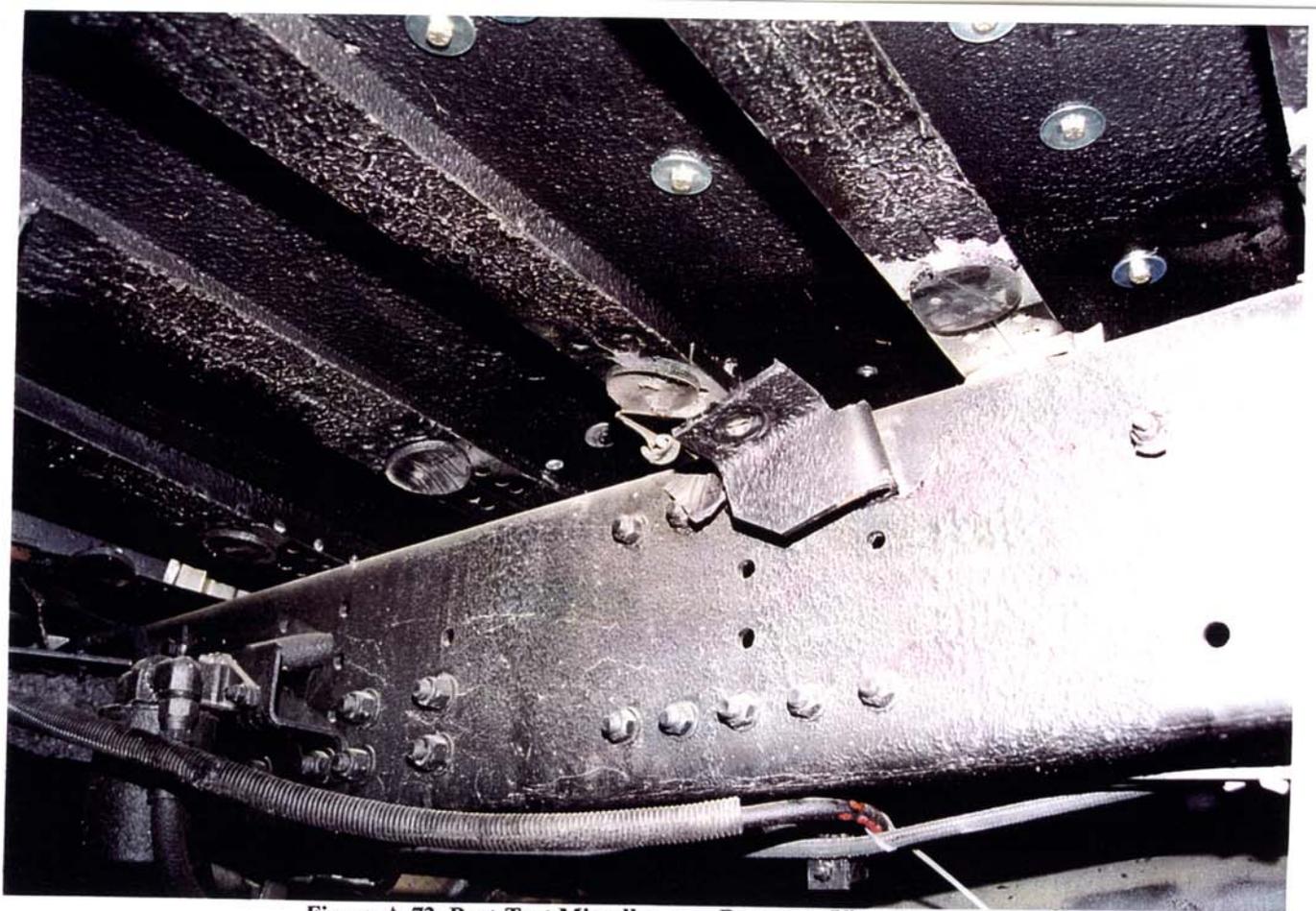


Figure A-72 Post-Test Miscellaneous Damage - View 7

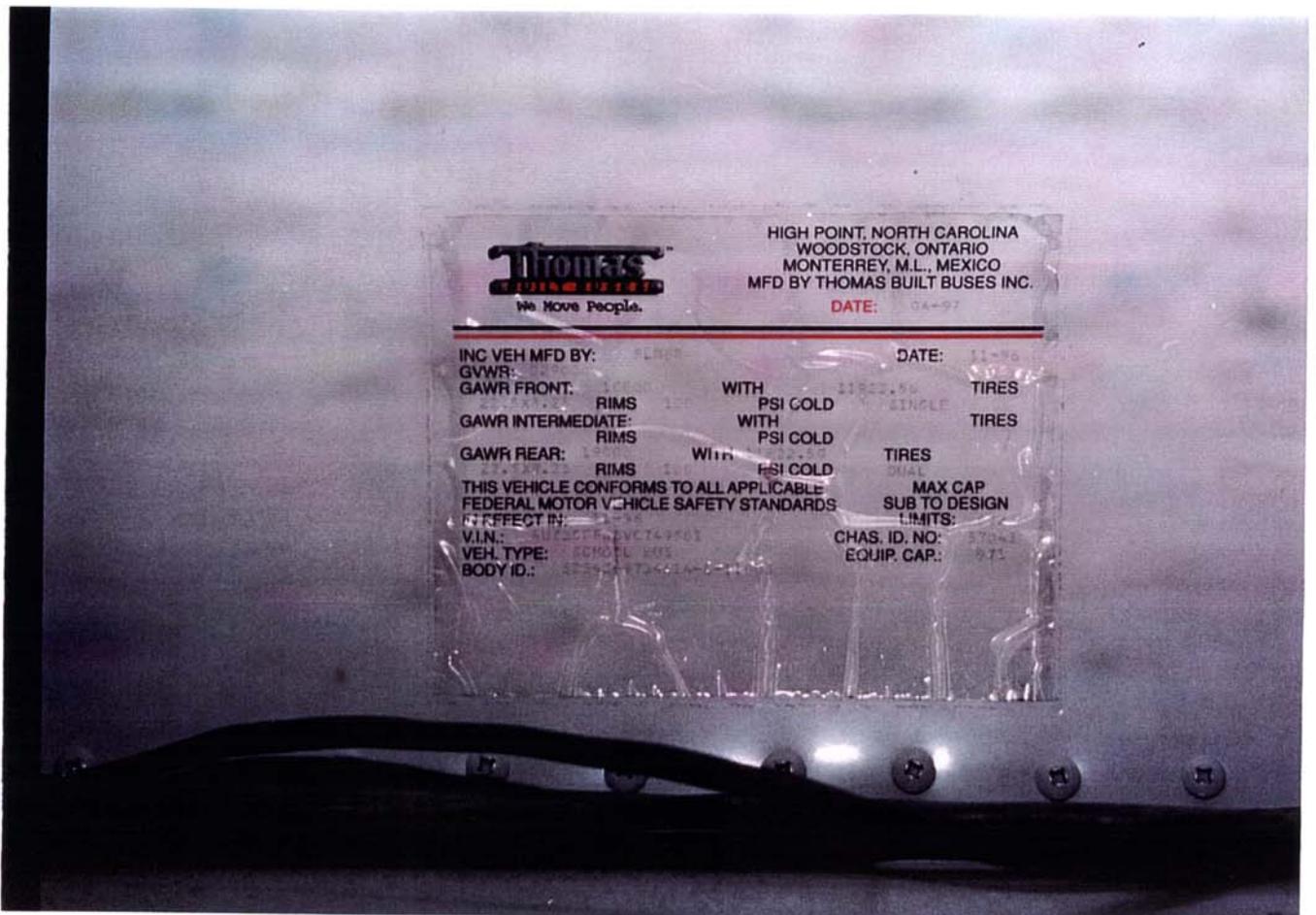
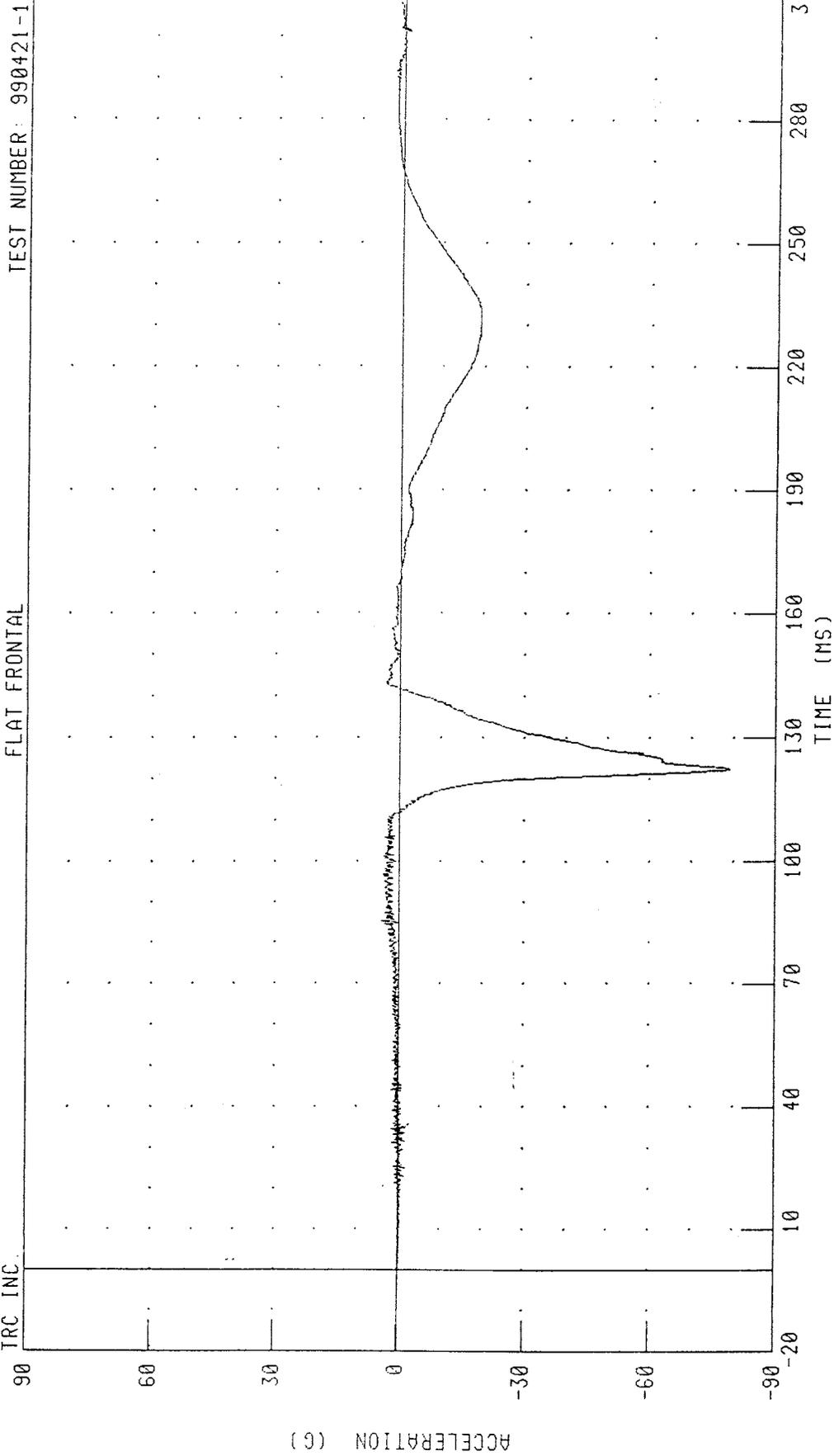


Figure A-73 Pre-Test Certification Label View

Appendix B

Data Plots

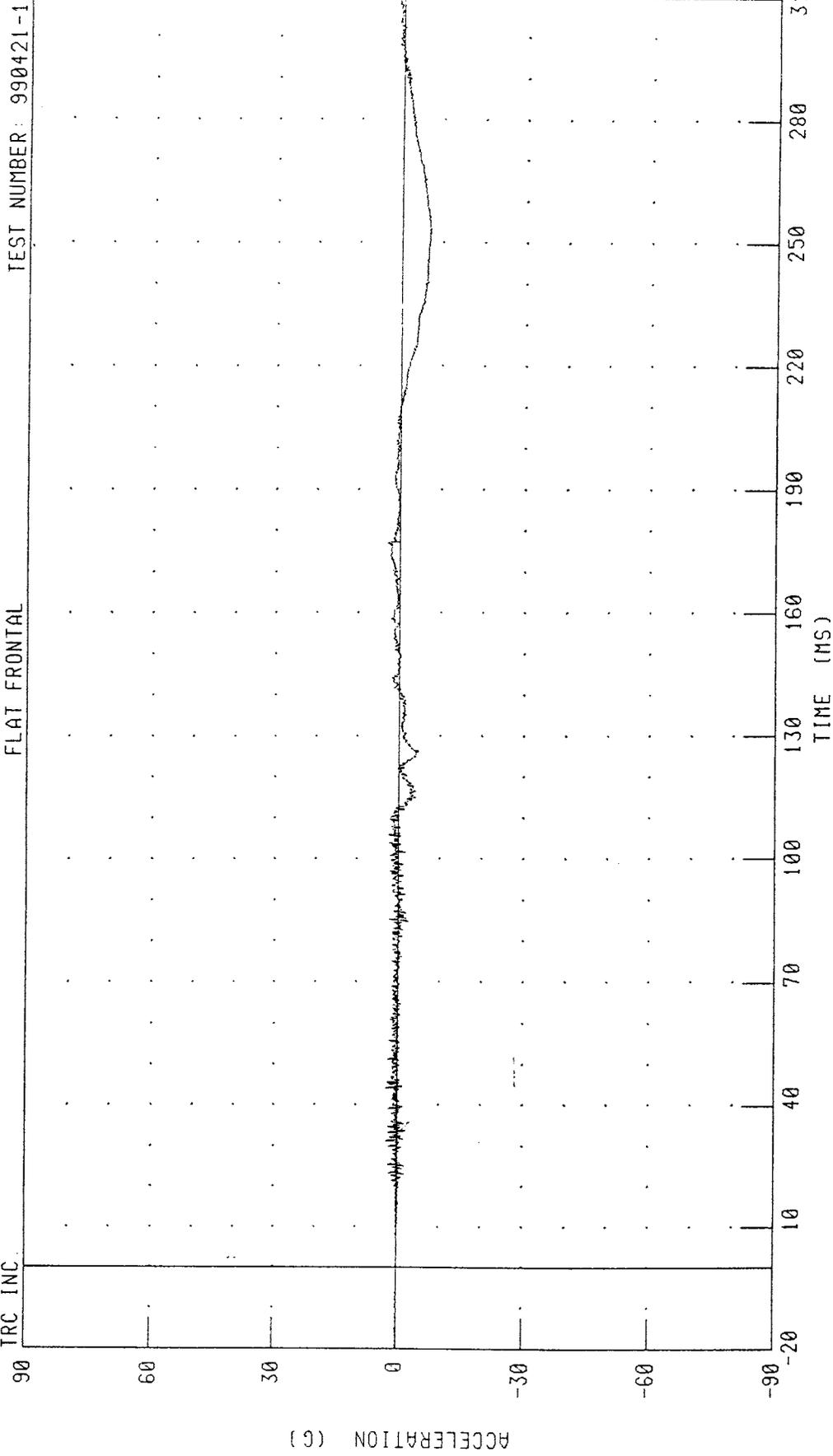
1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 HEAD X-AXIS ACCELERATION



CHANNEL: HEDXG1 FILTER: CH. CLASS 1000

PEAK DATA: 4.12 G @ 85.28 MS, -79.01 G @ 122.56 MS

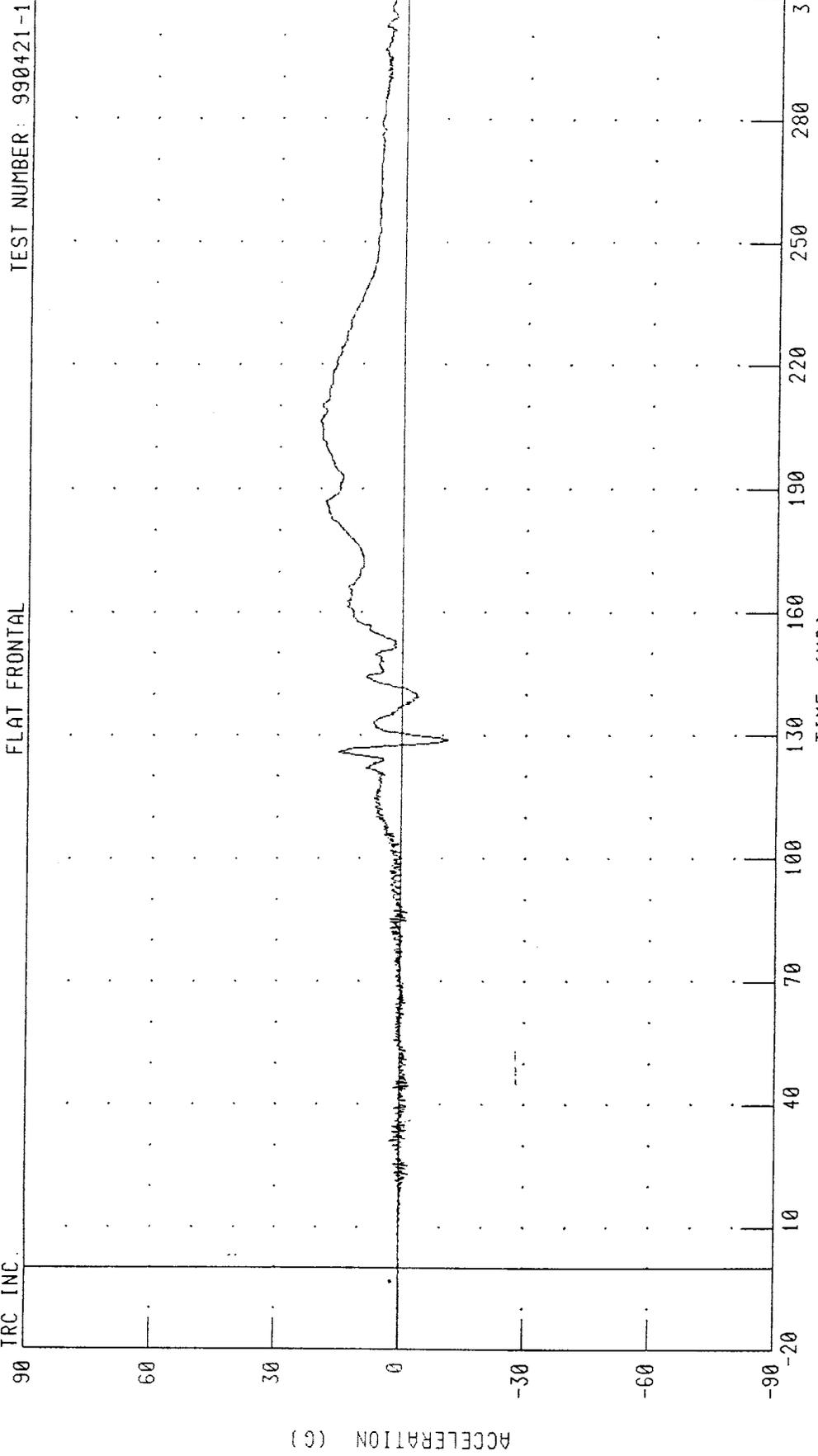
1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 HEAD Y-AXIS ACCELERATION



CHANNEL: HEDYG1 FILTER: CH. CLASS 1000

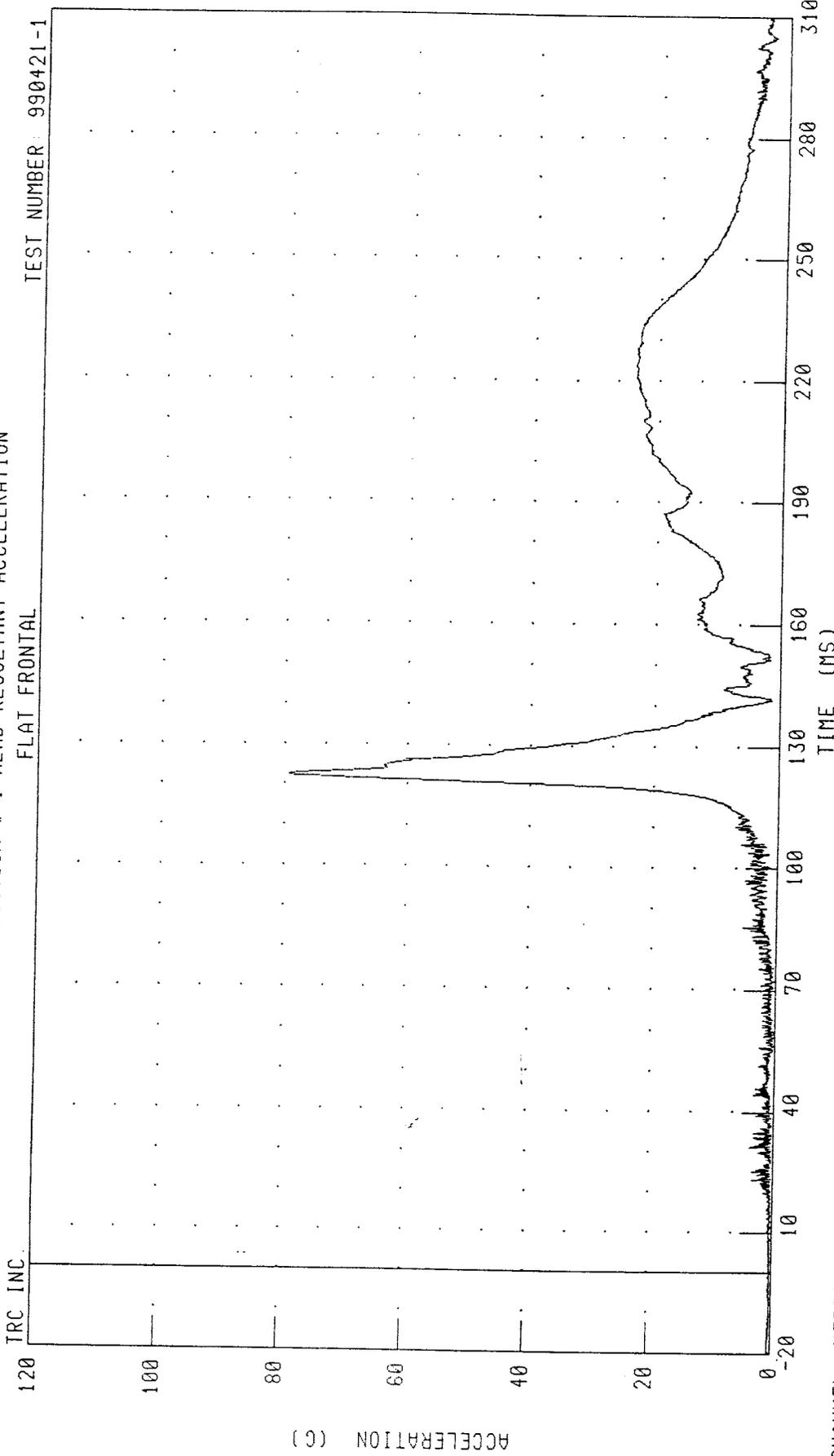
PEAK DATA: 2.85 G @ 177.04 MS, -6.93 G @ 250.72 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 HEAD Z-AXIS ACCELERATION



CHANNEL: HEDZG1 FILTER: CH. CLASS 1000 PEAK DATA: 20.18 G @ 206.00 MS, -11.17 G @ 128.96 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 HEAD RESULTANT ACCELERATION

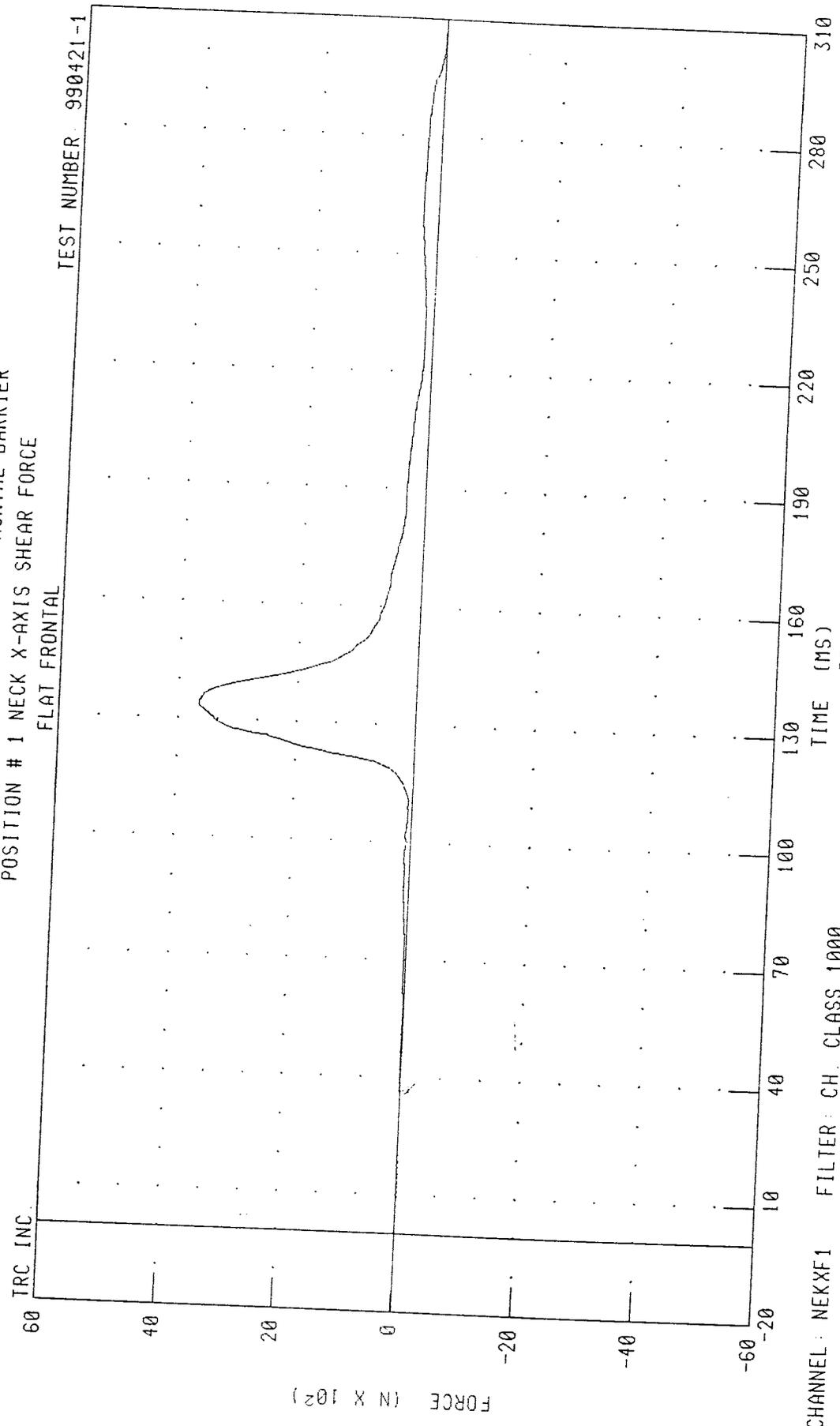


CHANNEL: HEDRC1 FILTER: CH. CLASS 1000

PEAK DATA: 79.40 G @ 122.56 MS; 0.13 G @ 56.40 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 NECK X-AXIS SHEAR FORCE  
FLAT FRONTAL

TEST NUMBER: 990421-1

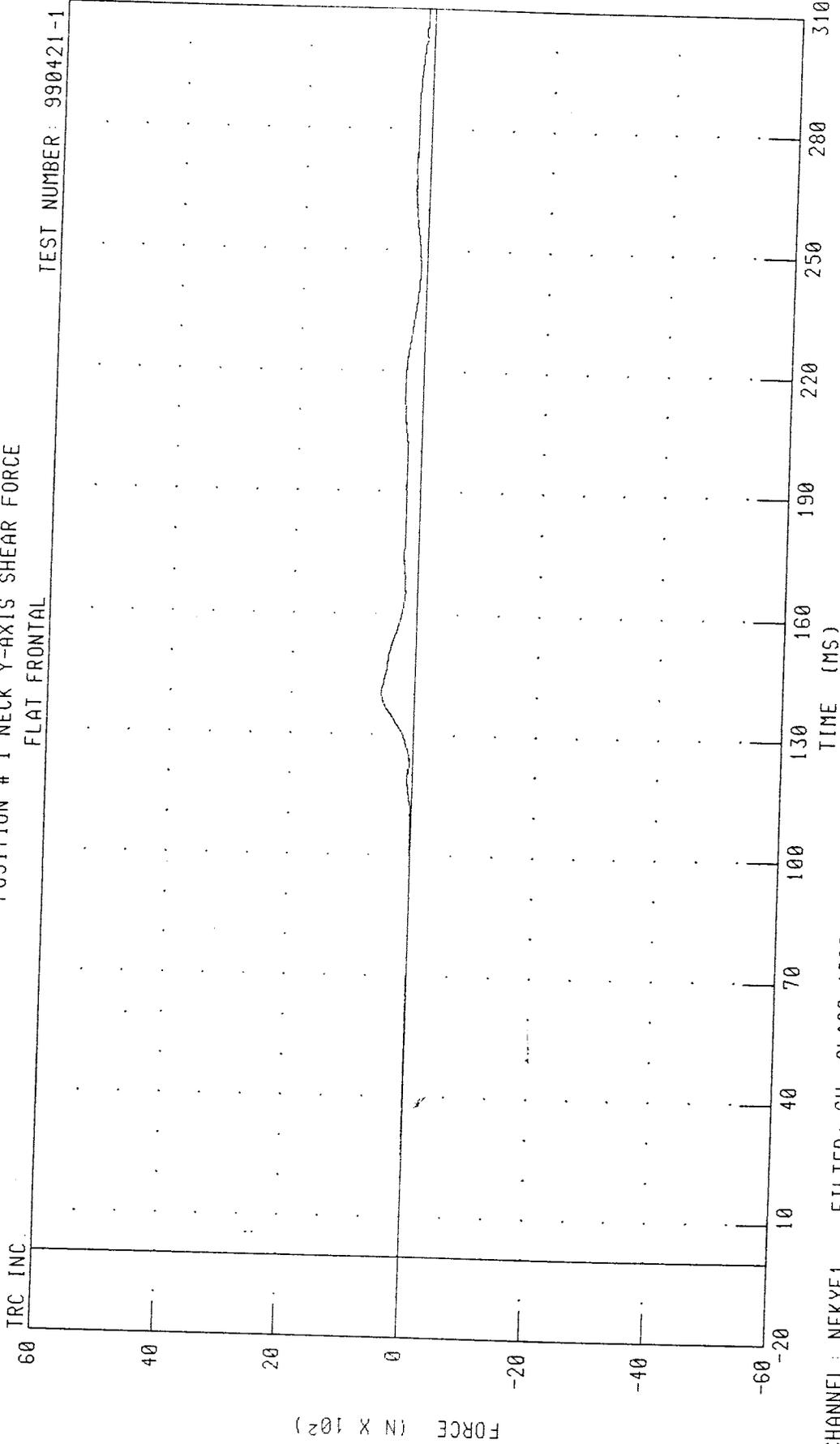


PEAK DATA: 3657.63 N @ 133.76 MS, -18.50 N @ 7.04 MS

CHANNEL: NEKXF1 FILTER: CH. CLASS 1000

TRC INC.

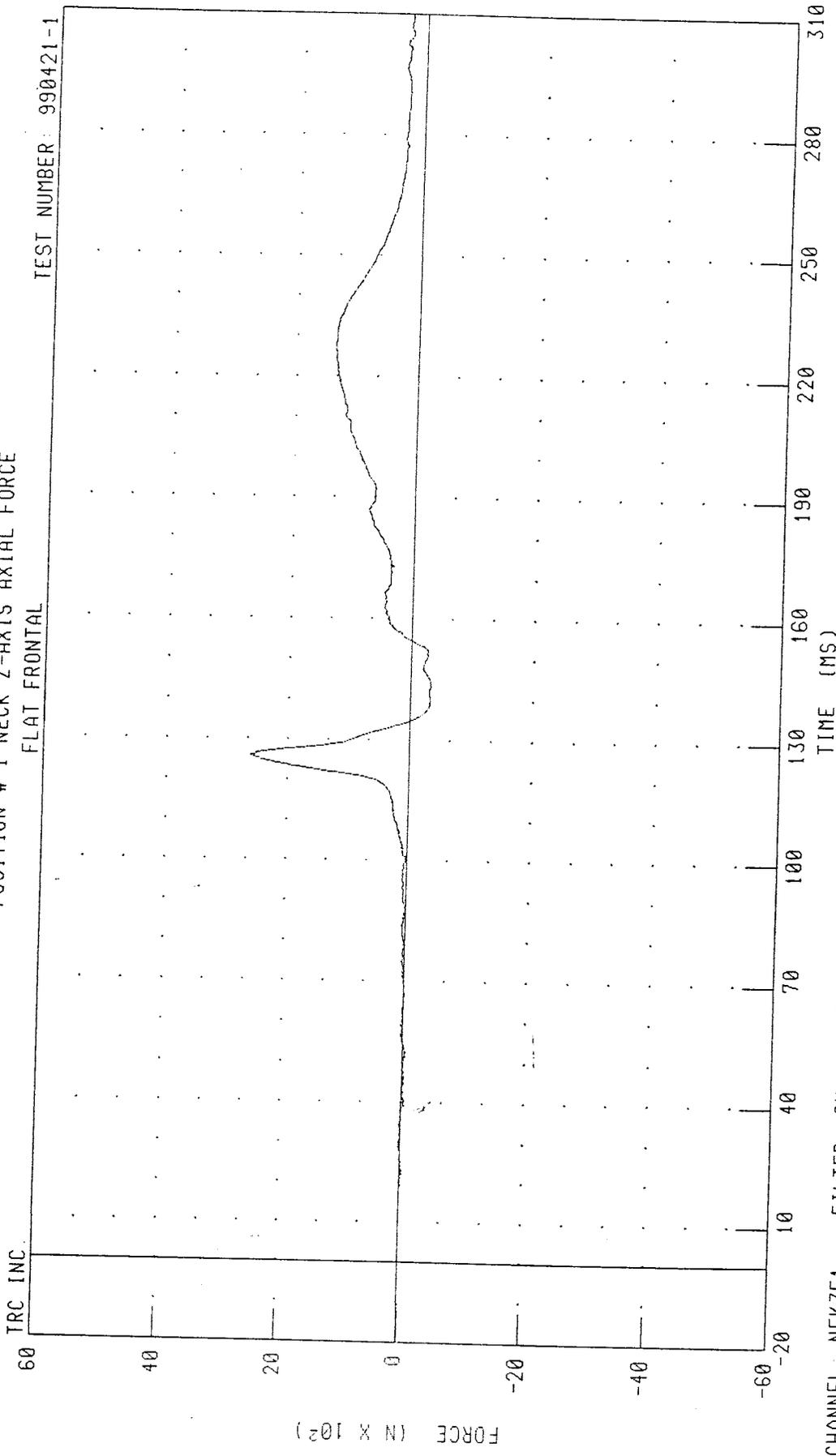
1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 NECK Y-AXIS SHEAR FORCE



CHANNEL: NEKYF1 FILTER: CH. CLASS 1000

PEAK DATA: 533.04 N @ 140.00 MS, -11.39 N @ 3.68 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 NECK Z-AXIS AXIAL FORCE  
FLAT FRONTAL



TEST NUMBER: 990421-1

TRC INC

CHANNEL: NEKZF1 FILTER: CH CLASS 1000

PEAK DATA: 2621.70 N @ 126.08 MS; -338.13 N @ 143.44 MS

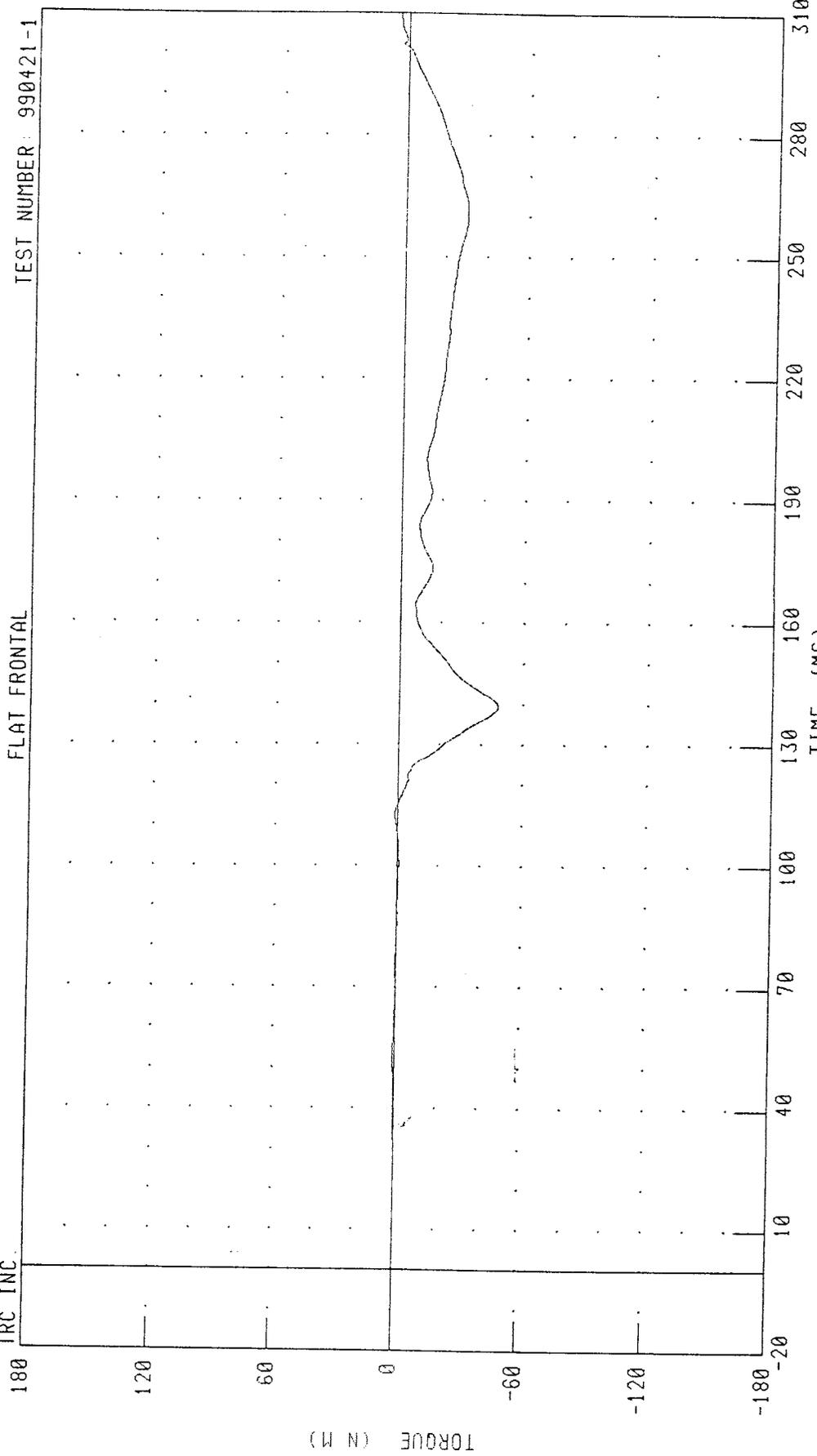
1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER

POSITION # 1 NECK MOMENT ABOUT X AXIS

FLAT FRONTAL

TEST NUMBER: 990421-1

TRC INC.



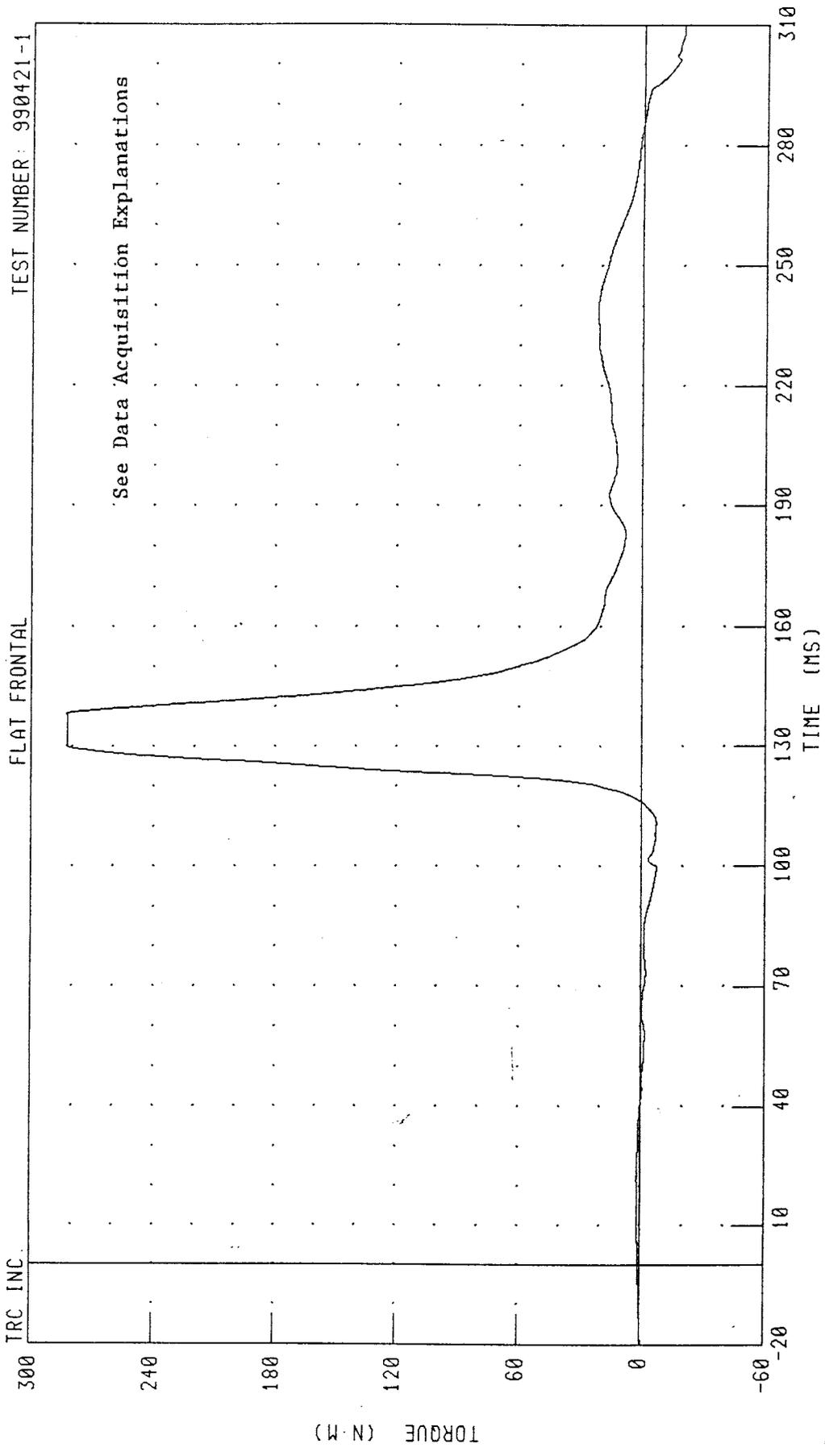
CHANNEL: NEKXMI

FILTER: CH. CLASS 600

TIME (MS)

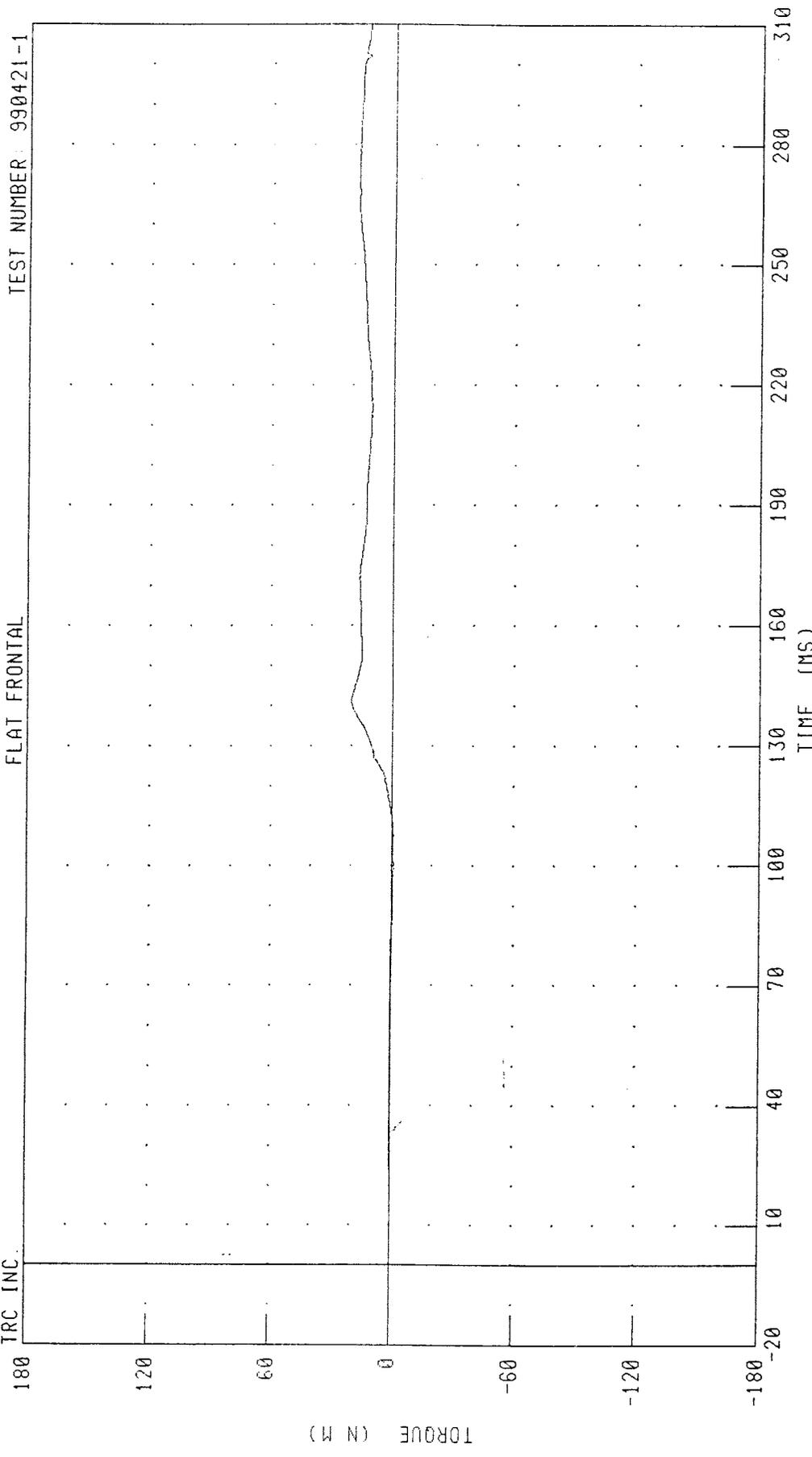
PEAK DATA: 3.86 N.M @ 309.76 MS; -47.92 N.M @ 139.60 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 NECK MOMENT ABOUT Y AXIS  
FLAT FRONTAL



CHANNEL: NEKYM1 FILTER: CH. CLASS 600  
PEAK DATA: 282.71 N·M @ 138.32 MS; -19.62 N·M @ 309.68 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 NECK MOMENT ABOUT Z AXIS  
FLAT FRONTAL



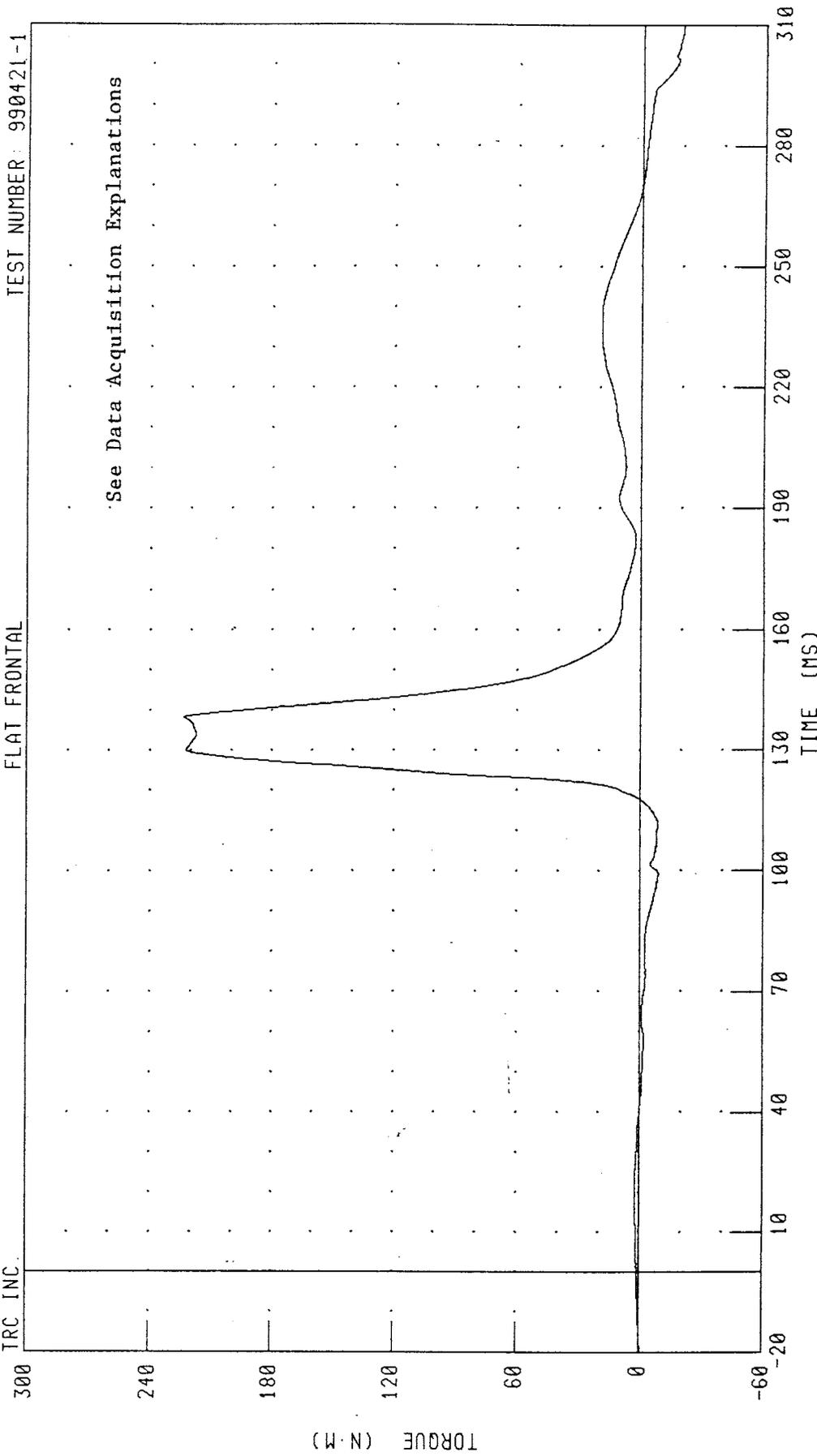
CHANNEL: NEKZM1 FILTER: CH. CLASS 600  
PEAK DATA: 20.09 N.M @ 141.52 MS, -1.14 N.M @ 99.44 MS  
TIME (MS)

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 NECK OCCIPITAL CONDYLE  
FLAT FRONTAL

TRC INC.

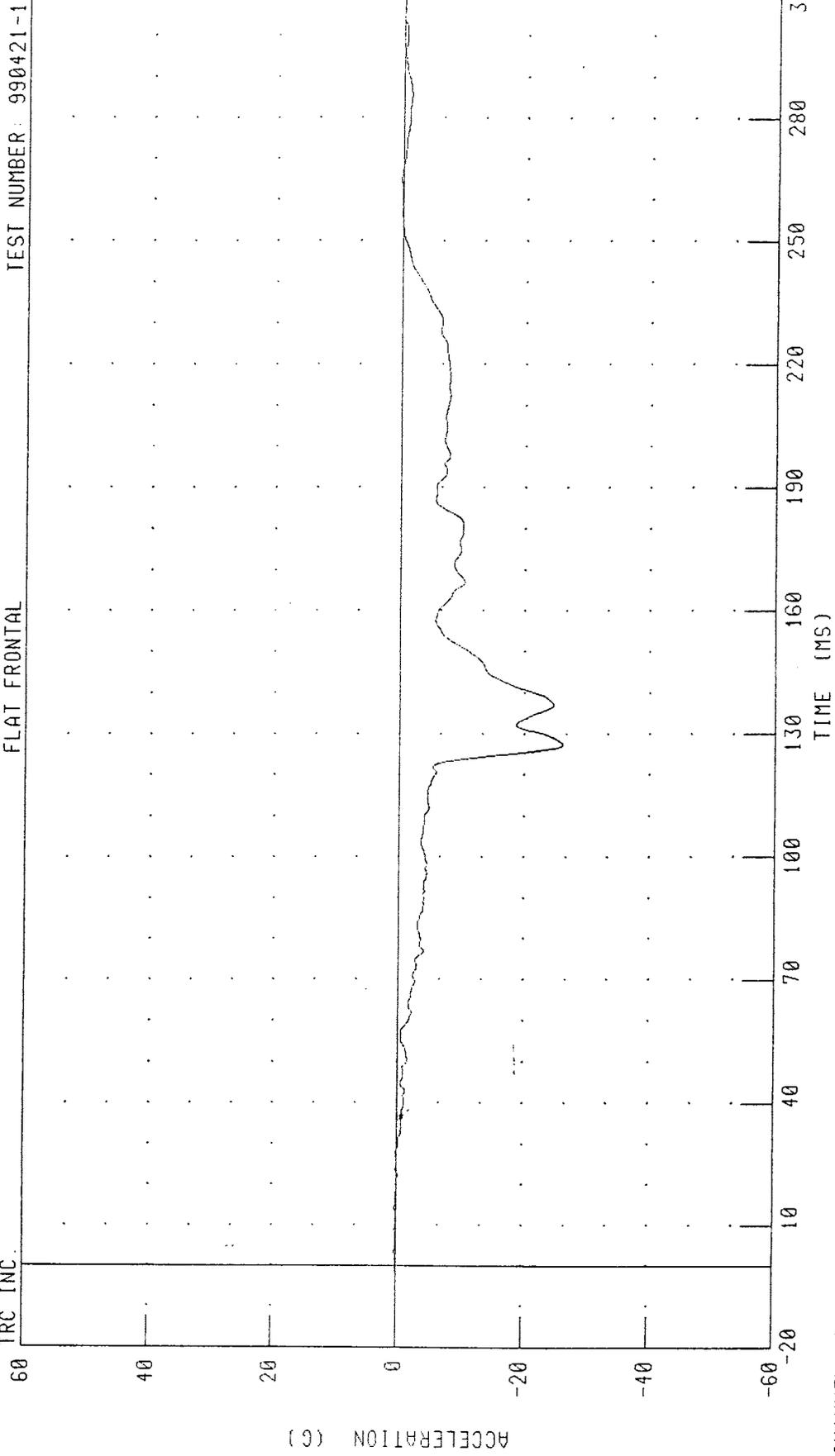
TEST NUMBER: 990421-1

See Data Acquisition Explanations



CHANNEL: NEKOM1 FILTER: CH. CLASS 600  
PEAK DATA: 223.57 N.M @ 138.40 MS; -19.42 N.M @ 309.60 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 CHEST X-AXIS ACCELERATION  
FLAT FRONTAL

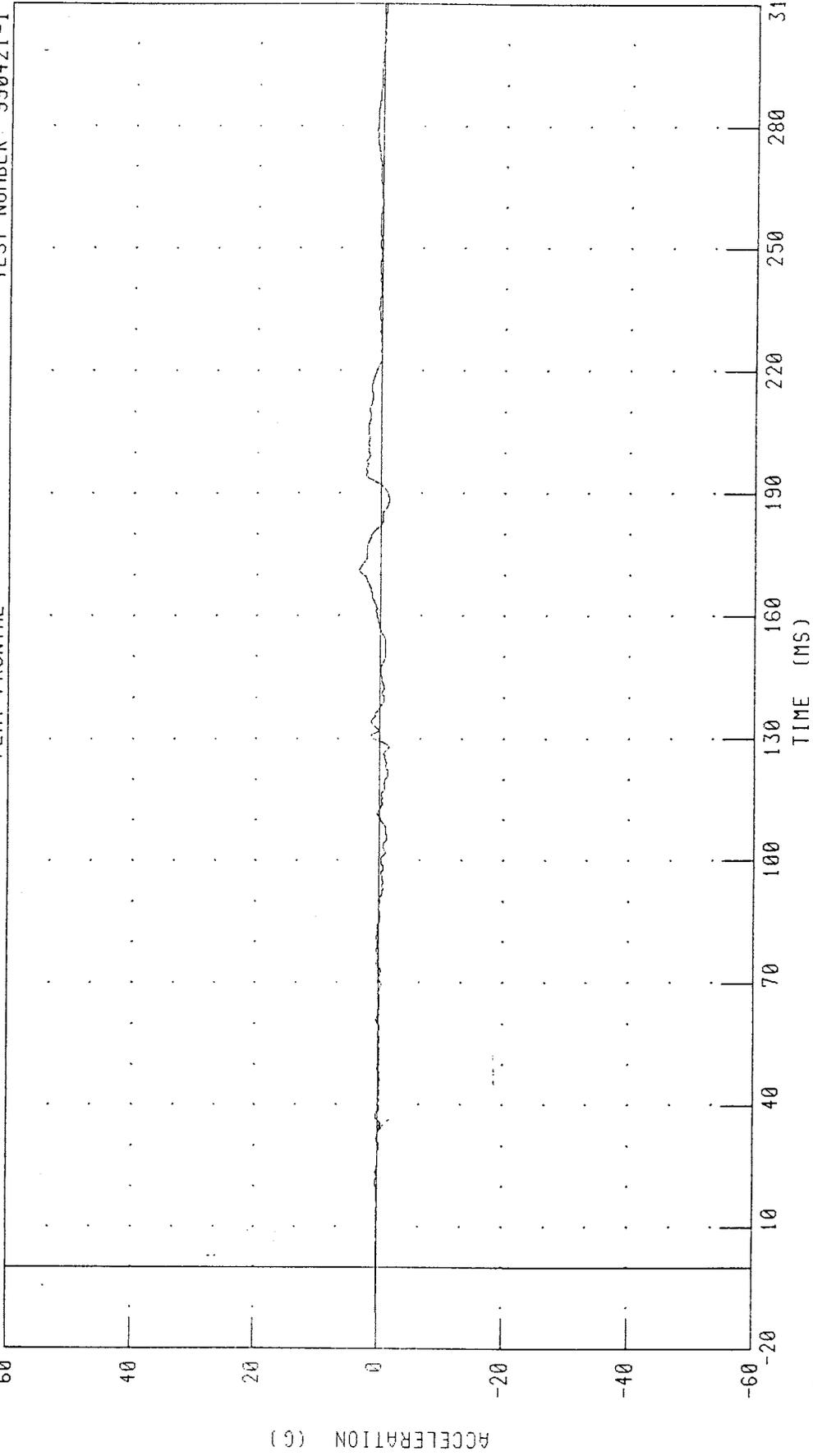


CHANNEL: CSTXG1 FILTER: CH. CLASS 180 PEAK DATA: 0.22 G @ 14.24 MS, -26.16 G @ 127.44 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 CHEST Y-AXIS ACCELERATION  
FLAT FRONTAL

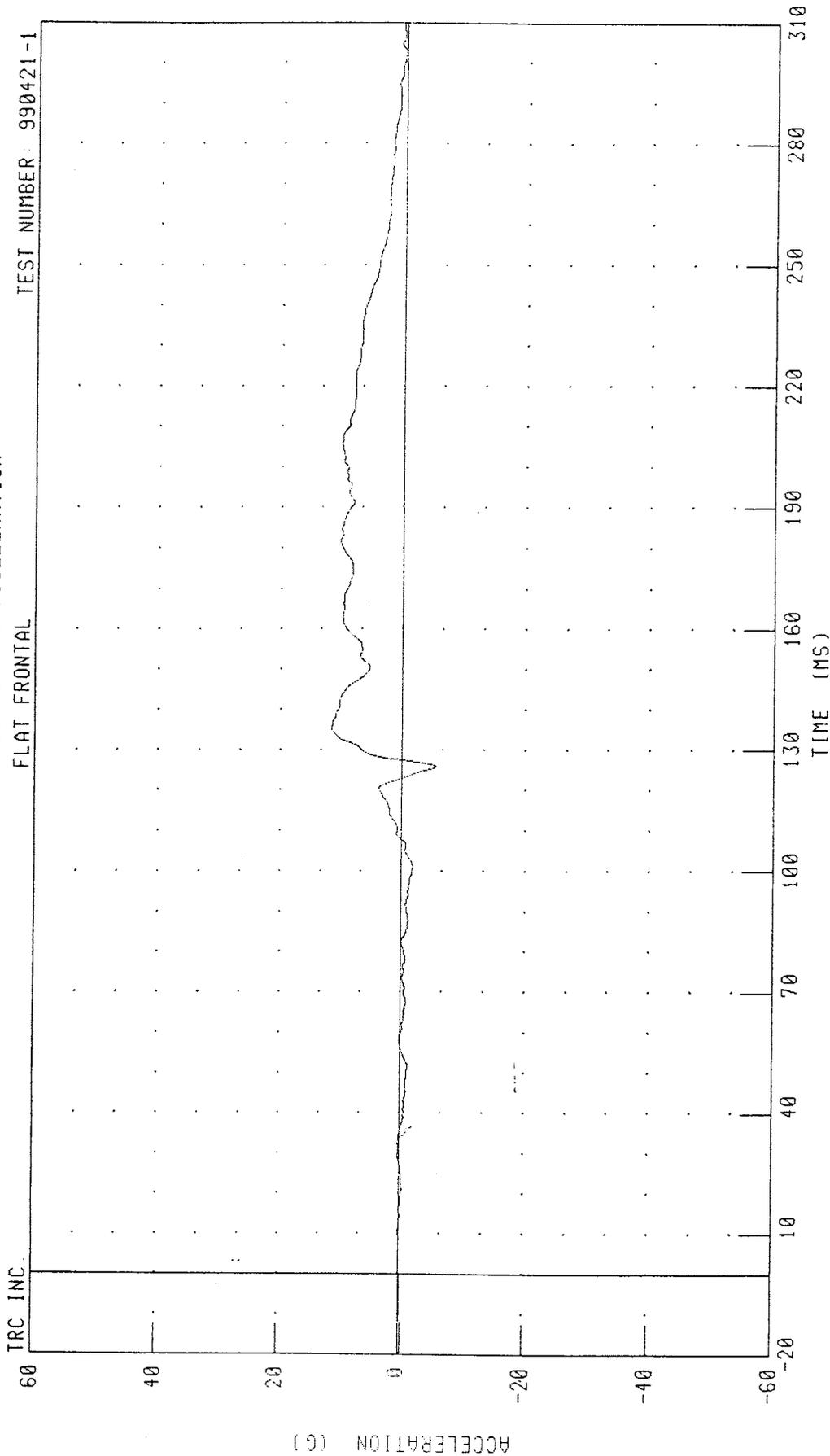
TRC INC.

TEST NUMBER: 990421-1



CHANNEL: CSTY61 FILTER: CH. CLASS 180 PEAK DATA: 3.43 G @ 171.20 MS; -1.61 G @ 128.16 MS

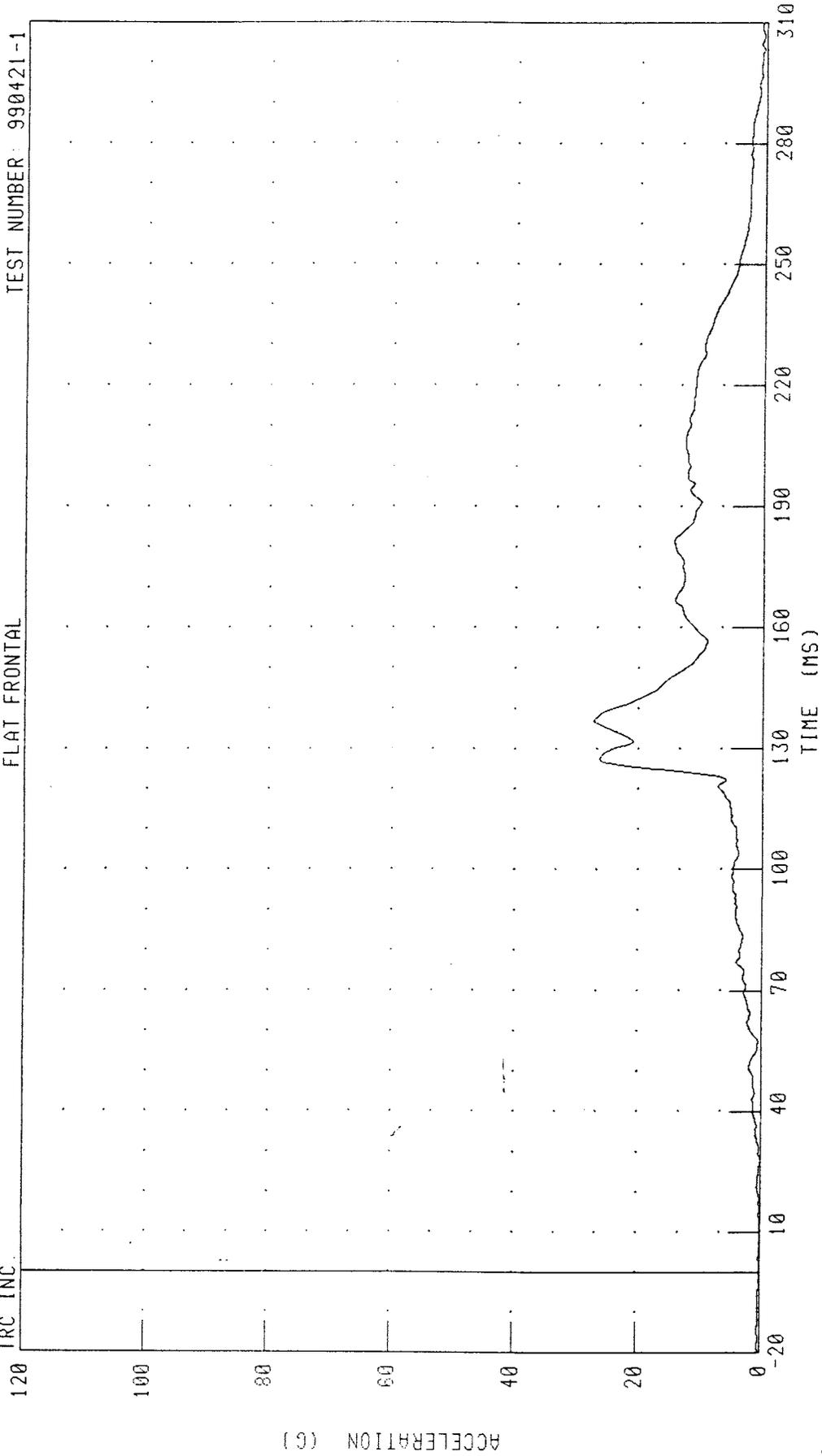
1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 CHEST Z-AXIS ACCELERATION  
FLAT FRONTAL



CHANNEL: CSTZG1 FILTER: CH. CLASS 180

PEAK DATA: 11.68 G @ 135.28 MS, -5.60 G @ 126.00 MS

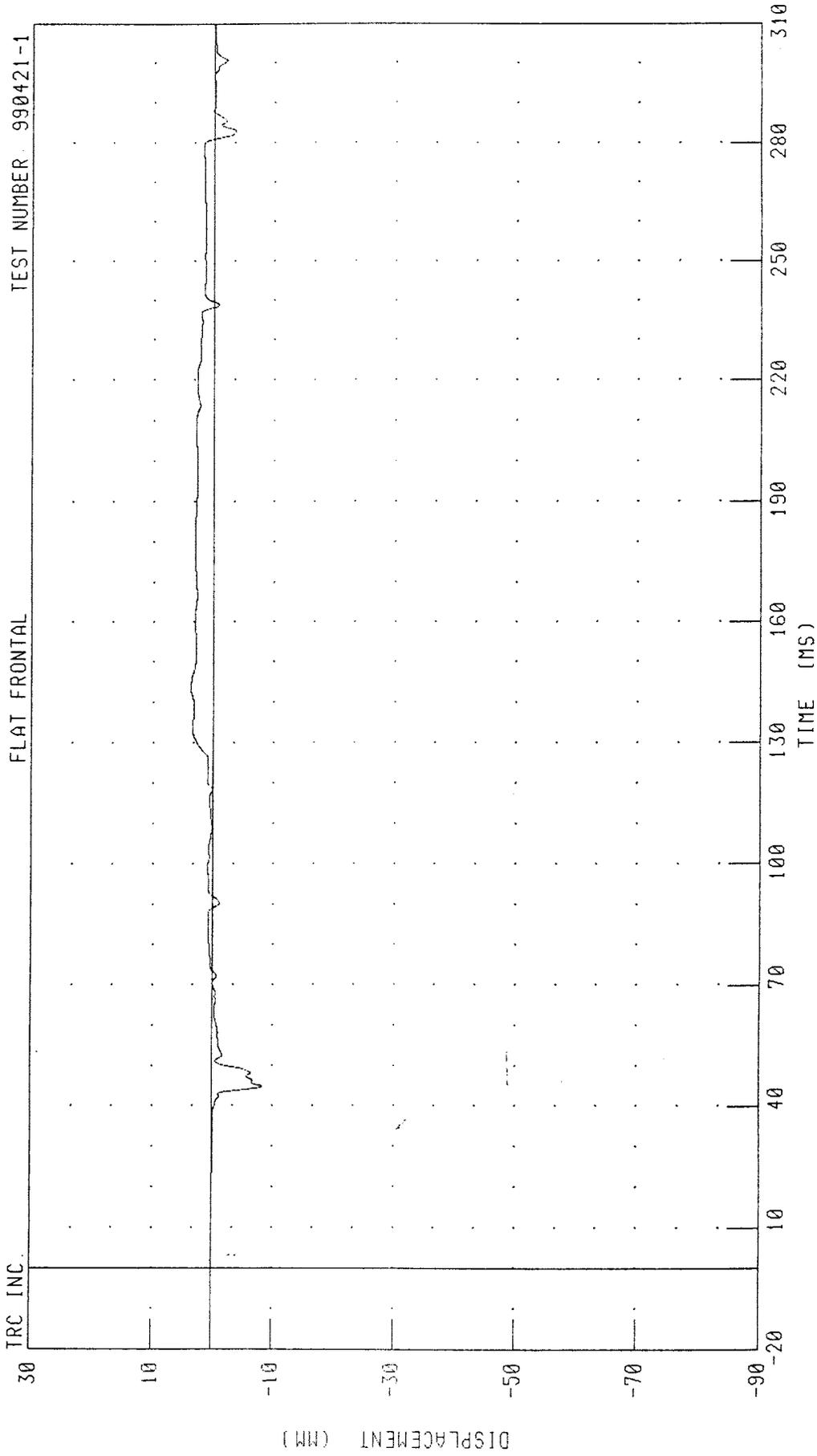
1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 CHEST RESULTANT ACCELERATION  
FLAT FRONTAL



CHANNEL: CSTRG1 FILTER: CH. CLASS 180

PEAK DATA: 27.18 G @ 137.12 MS, 0.03 G @ -20.00 MS

1997 THOMAS BUILT BUS INTO FLAT FRONTAL BARRIER  
POSITION # 1 CHEST DEFLECTION



CHANNEL: CSTXD1 FILTER: CH. CLASS 180

PEAK DATA: 3.80 MM @ 143.76 MS, -8.27 MM @ 44.96 MS

TRANSPORTATION RESEARCH CENTER INC.

RIGHT KNEE IMPACT TEST

HYBRID III 50th

16-APR-99

TRC INC.

TEST NO: 90C25RK1

572E SN 90 RIGHT KNEE CAL 25

TEST PARAMETER	SPECIFICATION	TEST RESULTS
TEMPERATURE	18.9-25.6 DEG. C	21.1 DEG. C
RELATIVE HUMIDITY	10 - 70 %	33.0 %
PROBE VELOCITY	2.07 - 2.13 M/S	2.10 M/S
PEAK KNEE IMPACT FORCE 5.0 KG PENDULUM	4715 - 5782 N	5525.8 N

TEST MEETS SPECIFICATIONS

TECHNICIAN

*Ry Calt*

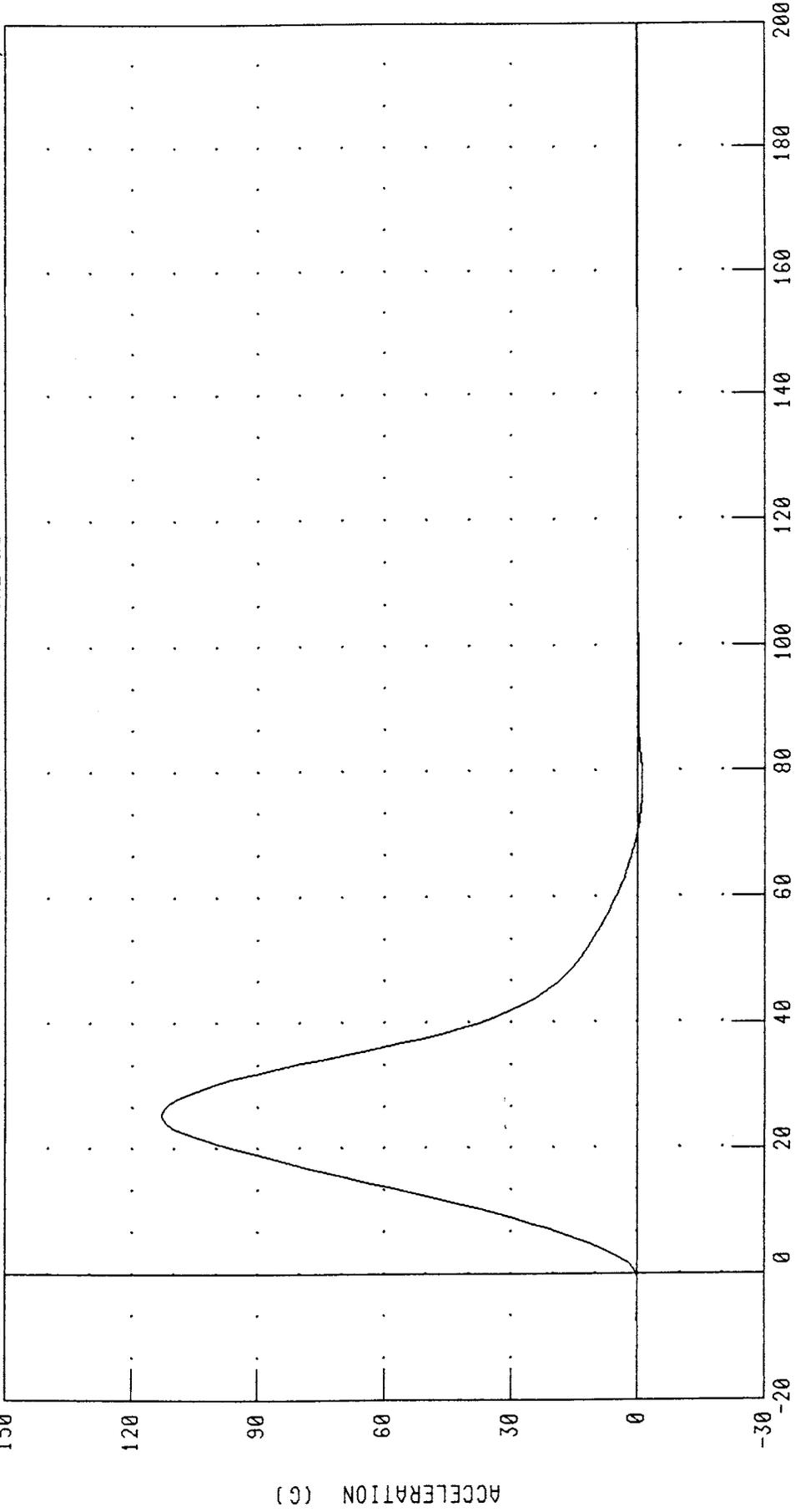
RUN NUMBER: 041599.0859;1

PART 572-E HYBRID III RIGHT KNEE CALIBRATION  
PENDULUM DECELERATION (5 KG PEND.)

TRC TEST NUMBER: 90C25RK1

572E SN 90 RIGHT KNEE CAL 25

RUN NUMBER: 041599.0859.1



TIME (MS X 10<sup>-1</sup>)

CHANNEL: PENXC FILTER: CH. CLASS 600

PEAK DATA: 112.94 G @ 2.56 MS; -1.18 G @ 7.84 MS

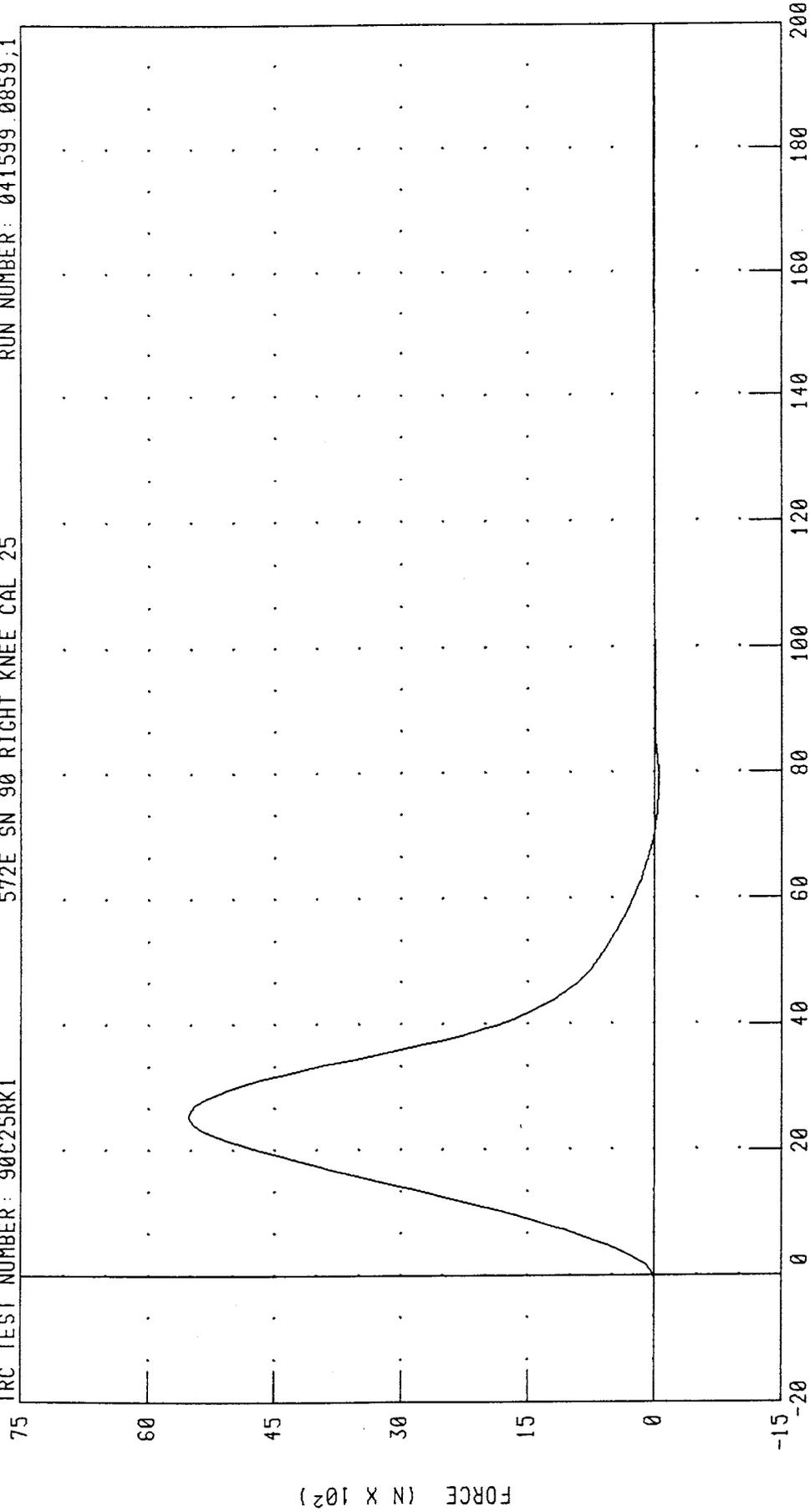
PART 572-E HYBRID III RIGHT KNEE CALIBRATION

PENDULUM FORCE (5 KG PEND.)

572E SN 90 RIGHT KNEE CAL 25

TRC TEST NUMBER: 90C25RK1

RUN NUMBER: 041599.0859;1



TIME (MS X 10<sup>-1</sup>)

CHANNEL: PENXF FILTER: CH. CLASS 600

PEAK DATA: 5525.90 N @ 2.56 MS; -57.93 N @ 7.84 MS

TRANSPORTATION RESEARCH CENTER INC.

LEFT KNEE IMPACT TEST

HYBRID III 50th

16-APR-99

TRC INC.

TEST NO: 90C25LK2

572E SN 90 LEFT KNEE CAL 25

TEST PARAMETER	SPECIFICATION	TEST RESULTS
TEMPERATURE	18.9-25.6 DEG. C	21.1 DEG. C
RELATIVE HUMIDITY	10 - 70 %	33.0 %
PROBE VELOCITY	2.07 - 2.13 M/S	2.10 M/S
PEAK KNEE IMPACT FORCE 5.0 KG PENDULUM	4715 - 5782 N	5084.5 N

TEST MEETS SPECIFICATIONS

TECHNICIAN

*By Cabt*

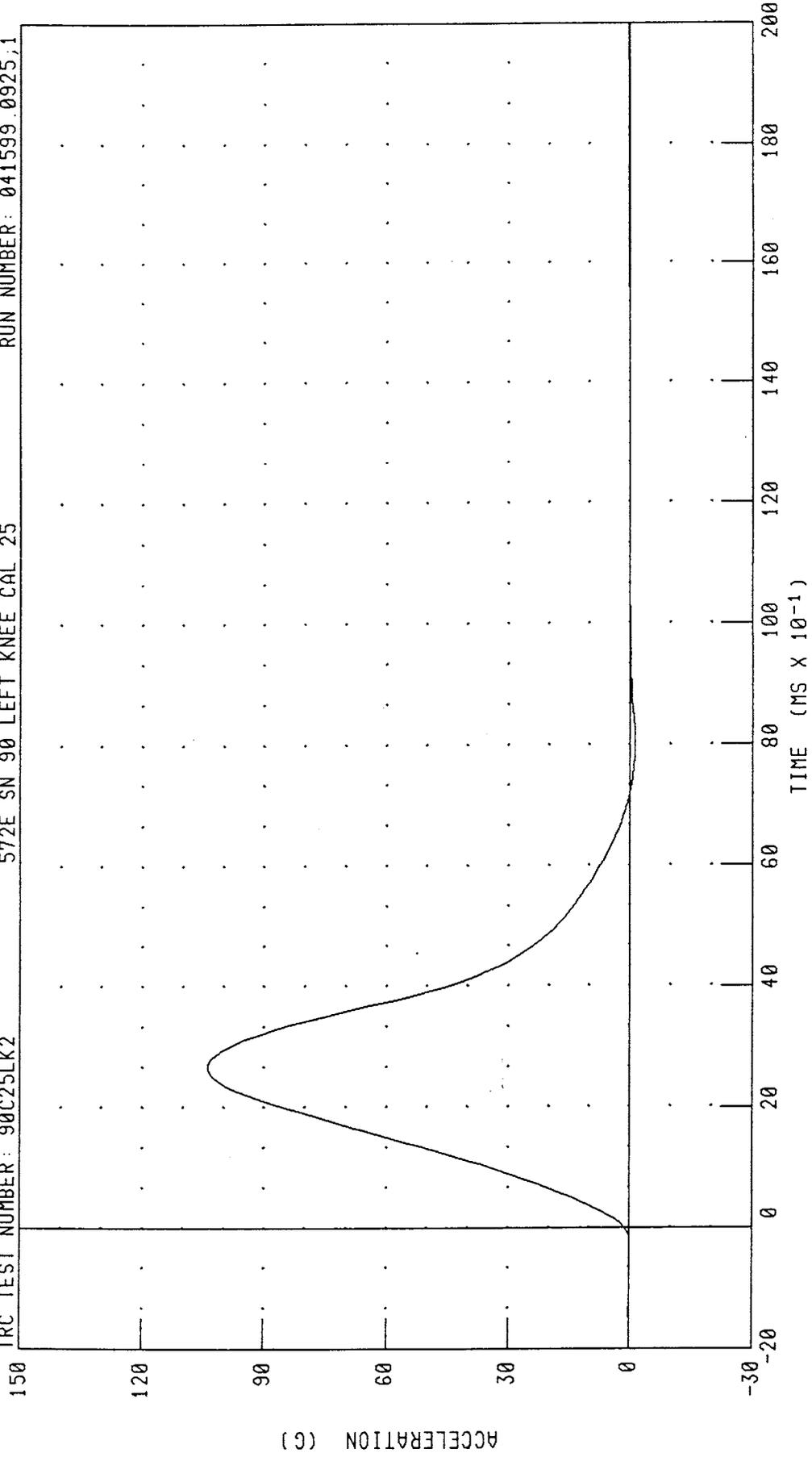
RUN NUMBER: 041599.0923;1

PART 572-E HYBRID III LEFT KNEE CALIBRATION  
PENDULUM DECELERATION (5 KG PEND.)

TRC TEST NUMBER: 90C25LK2

572E SN 90 LEFT KNEE CAL 25

RUN NUMBER: 041599.0925,1



CHANNEL: PENXG FILTER: CH. CLASS 600

PEAK DATA: 103.92 G @ 2.64 MS; -1.39 G @ 8.08 MS

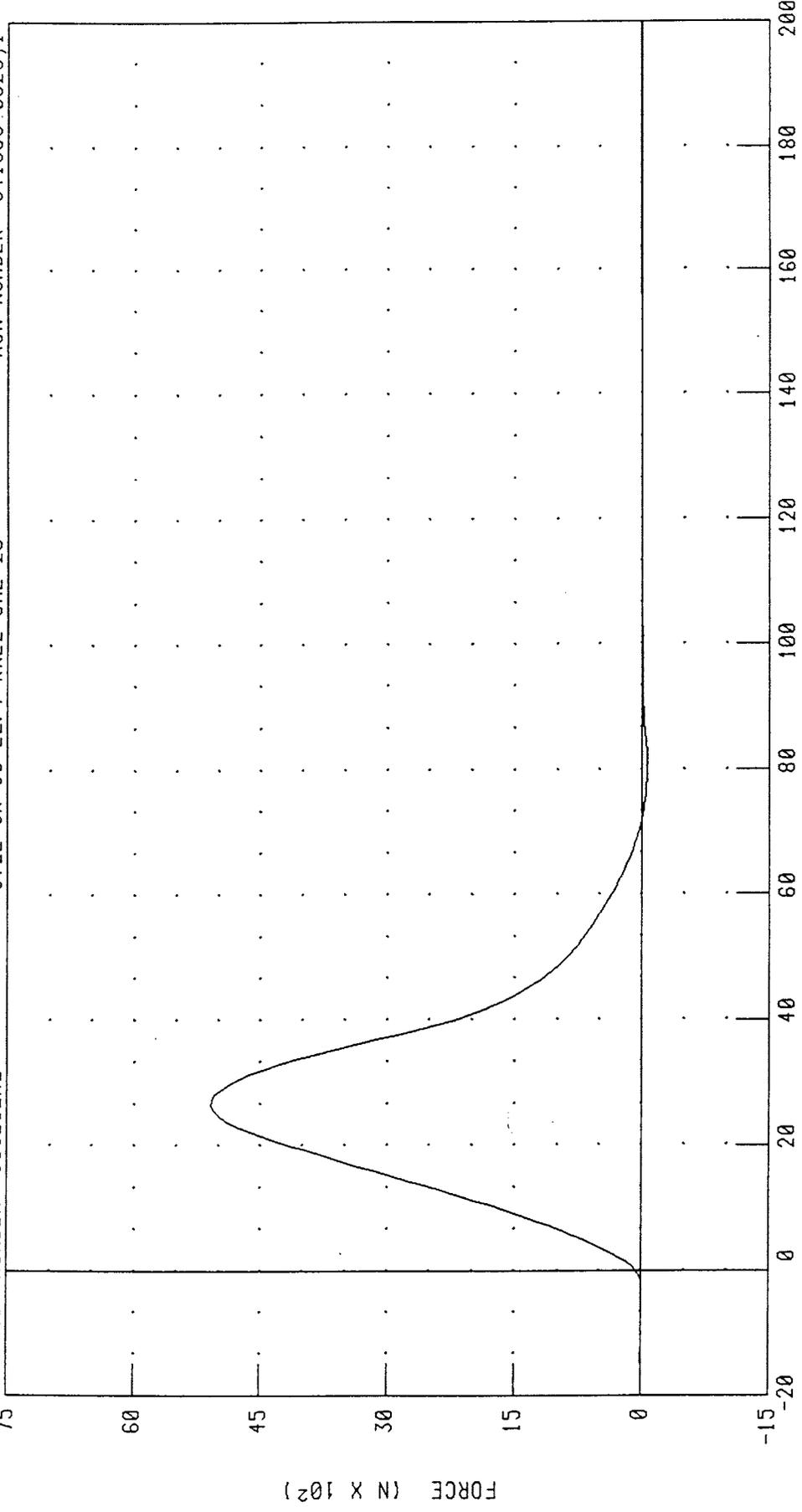
PART 572-E HYBRID III LEFT KNEE CALIBRATION

PENDULUM FORCE (5 KG PEND.)

TRC TEST NUMBER: 90C25LK2

572E SN 90 LEFT KNEE CAL 25

RUN NUMBER: 041599.0925,1



CHANNEL: PENXF FILTER: CH. CLASS 600

PEAK DATA: 5084.57 N @ 2.64 MS, -68.20 N @ 8.08 MS

## Appendix D

### Miscellaneous Test Information

## Dummy Sign Convention

Accelerometers: +X: Forward  
+Y: Rightward  
+Z: Upward

Potentiometers: +Chest longitudinal deflection: Outward

Load cells: +Femur force: Tension

Neck load cells: +X force: Head rearward  
+Y force: Head leftward  
+Z force: Head upward (tension on neck)  
+X moment: Left ear rotating toward left shoulder  
+Y moment: Chin rotating toward chest  
+Z moment: Chin rotating toward left shoulder

Filtering Data

J211 MAR95

Load Cell Barrier Forces Class 60

Vehicle Structural Accelerations Class 60

Occupant

Head Accelerometer Class 1000

Neck Class 60

Chest Accelerometer Class 180

Chest Deflection Class 180

Femur Force Class 600

Sternum Accelerometer Class 180

Lower Leg Class 600

## Dummy Instrumentation Placement

Dummy Manufacturer and S/N: Humanetics/45

Seating position: Position #1 (50<sup>th</sup>)

<u>Mnemonic</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Serial Number</u>	<u>Orientation (+ Sensing)</u>
HEDXG1	Head	X	Endevco	7264-2000T	AJ4L1	Rear
HEDYG1	Head	Y	Endevco	7264-2000T	J23996	Left
HEDZG1	Head	Z	Endevco	7264-2000T	EJ97J	Up
NEKXF1	Neck	X	Denton	1716A	851FX	Head forward
NEKYF1	Neck	Y	Denton	1716A	851FY	Head leftward
NEKZF1	Neck	Z	Denton	1716A	851FZ	Head upward (tension)
NEKXM1	Neck	X	Denton	1716A	851MX	Right ear to Right shoulder
NEKYM1	Neck	Y	Denton	1716A	851MY	Chin to chest
NEKZM1	Neck	Z	Denton	1716A	851MZ	Chin to left shoulder
CSTXG1	Chest	X	Endevco	7264-2000T	AJ7W9	Rearward
CSTYG1	Chest	Y	Endevco	7264-2000T	J21989	Left
CSTZG1	Chest	Z	Endevco	7264-2000T	BE95J	Down
CSTXD1	Chest	X	Servo	14CB1-2897	86696-1	Outward
PEVXG1	Pelvis	X	Endevco	7264-2000T	AJ4F8	Rearward
PEVYG1	Pelvis	Y	Endevco	7264-2000T	AJ7G7	Left
PEVZG1	Pelvis	Z	Endevco	7264-2000T	J19338	Up
LFMZF1	Left femur	Z	Denton	1914A	363FZ	Tension
RFMZF1	Right femur	Z	Denton	1914A	362FZ	Tension

Dummy Instrumentation Placement, Cont'd.

Dummy Manufacturer and S/N: First Technologies/027

Seating position: Position #2 (6YO)

<u>Mnemonic</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Serial Number</u>	<u>Orientation (+ Sensing)</u>
HEDXG2	Head	X	Endevco	7264-2000T	AJ4N7	Forward
HEDYG2	Head	Y	Endevco	7264-2000T	J22038	Right
HEDZG2	Head	Z	Endevco	7264-2000T	ALAB9	Up
NEKXF2	Neck	X	Denton	1716A	810FX	Head forward
NEKYF2	Neck	Y	Denton	1716A	810FY	Head leftward
NEKZF2	Neck	Z	Denton	1716A	810FZ	Head upward (tension)
NEKXM2	Neck	X	Denton	1716A	810MX	Right ear to Right shoulder
NEKYM2	Neck	Y	Denton	1716A	810MY	Chin to chest
NEKZM2	Neck	Z	Denton	1716A	810MZ	Chin to left shoulder
CSTXG2	Chest	X	Endevco	7264-2000T	J23941	Forward
CSTYG2	Chest	Y	Endevco	7264-2000T	J14190	Left
CSTZG2	Chest	Z	Endevco	7264-2000T	BD15J	Down
CSTXD2	Chest	X	Servo	14CB1-2897	027	Outward
PEVXG2	Pelvis	X	Endevco	7264-2000T	J23944	Forward
PEVYG2	Pelvis	Y	Endevco	7264-2000T	J20047	Left
PEVZG2	Pelvis	Z	Endevco	7264-2000T	J23805	Up
LFMZF2	Left femur	Z	Denton	T11654	005	Tension
RFMZF2	Right femur	Z	Denton	T11654	008	Tension

Dummy Instrumentation Placement, Cont'd.

Dummy Manufacturer and S/N: First Technologies/088

Seating position: Position #3 (6YO)

<u>Mnemonic</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Serial Number</u>	<u>Orientation (+ Sensing)</u>
HEDXG3	Head	X	Endevco	7264-2000T	J23803	Forward
HEDYG3	Head	Y	Endevco	7264-2000T	J23947	Right
HEDZG3	Head	Z	Endevco	7264-2000T	AJ451	Up
NEKXF3	Neck	X	Denton	1716A	798FX	Head forward
NEKYF3	Neck	Y	Denton	1716A	798FY	Head leftward
NEKZF3	Neck	Z	Denton	1716A	798FZ	Head upward (tension)
NEKXM3	Neck	X	Denton	1716A	798MX	Right ear to Right shoulder
NEKYM3	Neck	Y	Denton	1716A	798MY	Chin to chest
NEKZM3	Neck	Z	Denton	1716A	798MZ	Chin to left shoulder
CSTXG3	Chest	X	Endevco	7264-2000T	ACC65	Forward
CSTYG3	Chest	Y	Endevco	7264-2000T	DW83J	Left
CSTZG3	Chest	Z	Endevco	7264-2000T	AJ4L3	Down
CSTXD3	Chest	X	Servo	14CB1-2897	088	Outward
PEVXG3	Pelvis	X	Endevco	7264-2000T	J23998	Forward
PEVYG3	Pelvis	Y	Endevco	7264-2000T	J23832	Left
PEVZG3	Pelvis	Z	Endevco	7264-2000T	AJ4J6	Up
LFMZF3	Left femur	Z	Denton	2090	125	Tension
RFMZF3	Right femur	Z	Denton	2090	126	Tension

Dummy Instrumentation Placement, Cont'd.

Dummy Manufacturer and S/N: First Technologies/289

Seating position: Position #4 (5<sup>th</sup>)

<u>Mnemonic</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Serial Number</u>	<u>Orientation (+ Sensing)</u>
HEDXG4	Head	X	Endevco	7264-2000T	J20165	Forward
HEDYG4	Head	Y	Endevco	7264-2000T	J19865	Right
HEDZG4	Head	Z	Endevco	7264-2000T	J19934	Up
NEKXF4	Neck	X	Denton	1716	0425FX	Head forward
NEKYF4	Neck	Y	Denton	1716	0425FY	Head leftward
NEKZF4	Neck	Z	Denton	1716	0425FZ	Head upward (tension)
NEKXM4	Neck	X	Denton	1716	0425MX	Right ear to Right shoulder
NEKYM4	Neck	Y	Denton	1716	0425MY	Chin to chest
NEKZM4	Neck	Z	Denton	1716	0425MZ	Chin to left shoulder
CSTXG4	Chest	X	Endevco	7264-2000T	J20599	Forward
CSTYG4	Chest	Y	Endevco	7264-2000T	J20580	Left
CSTZG4	Chest	Z	Endevco	7264-2000T	EH88J	Up
CSTXD4	Chest	X	Servo	14CB1-2897	019	Outward
PEVXG4	Pelvis	X	Endevco	7264-2000T	CY06H	Rearward
PEVYG4	Pelvis	Y	Endevco	7264-2000T	AGAC4	Left
PEVZG4	Pelvis	Z	Endevco	7264-2000T	BF65J	Up
LFMZF4	Left femur	Z	Denton	1914	0259FZ	Tension
RFMZF4	Right femur	Z	Denton	1914	0257FZ	Tension

Dummy Instrumentation Placement, Cont'd.

Dummy Manufacturer and S/N: First Technologies/329

Seating position: Position #5 (5<sup>th</sup>)

<u>Mnemonic</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Serial Number</u>	<u>Orientation (+ Sensing)</u>
HEDXG5	Head	X	Entran	EGE-73BQ-2000B	98H10-F16	Rear
HEDYG5	Head	Y	Entran	EGE-73BQ-2000B	98H14-K2	Left
HEDZG5	Head	Z	Entran	EGE-73BQ-2000B	98H13-F04	Up
NEKXF5	Neck	X	Denton	1716A	1039FX	Head forward
NEKYF5	Neck	Y	Denton	1716A	1039FY	Head leftward
NEKZF5	Neck	Z	Denton	1716A	1039FZ	Head upward (tension)
NEKXM5	Neck	X	Denton	1716A	1039MX	Right ear to Right shoulder
NEKYM5	Neck	Y	Denton	1716A	1039MY	Chin to chest
NEKZM5	Neck	Z	Denton	1716A	1039MZ	Chin to left shoulder
CSTXG5	Chest	X	Entran	EGE-73BQ-2000B	98H13-F05	Forward
CSTYG5	Chest	Y	Entran	EGE-73BQ-2000B	98H13-F07	Left
CSTZG5	Chest	Z	Entran	EGE-73BQ-2000B	98H10-F10	Down
CSTXD5	Chest	X	Servo	14CB1-2897	329F	Outward
PEVXG5	Pelvis	X	Entran	EGE-73BQ-2000B	98H10-F19	Rearward
PEVYG5	Pelvis	Y	Entran	EGE-73BQ-2000B	98H10-F12	Left
PEVZG5	Pelvis	Z	Entran	EGE-73BQ-2000B	98H13-F01	Up
LFMZ5	Left femur	Z	Denton	1914A	376FZ	Tension
RFMZ5	Right femur	Z	Denton	1914A	383FZ	Tension

Dummy Instrumentation Placement, Cont'd.

Dummy Manufacturer and S/N: Alderson Research Laboratories/90

Seating position: Position #6 (50<sup>th</sup>)

<u>Mnemonic</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Serial Number</u>	<u>Orientation (+ Sensing)</u>
HEDXG6	Head	X	Endevco	7264-2000T	J23802	Rear
HEDYG6	Head	Y	Endevco	7264-2000T	J23911	Left
HEDZG6	Head	Z	Endevco	7264-2000T	J23942	Up
NEKXF6	Neck	X	Denton	1716A	852FX	Head forward
NEKYF6	Neck	Y	Denton	1716A	852FY	Head leftward
NEKZF6	Neck	Z	Denton	1716A	852FZ	Head upward (tension)
NEKXM6	Neck	X	Denton	1716A	852MX	Right ear to Right shoulder
NEKYM6	Neck	Y	Denton	1716A	852MY	Chin to chest
NEKZM6	Neck	Z	Denton	1716A	852MZ	Chin to left shoulder
CSTXG6	Chest	X	Endevco	7264-2000T	J24017	Forward
CSTYG6	Chest	Y	Endevco	7264-2000T	J23759	Left
CSTZG6	Chest	Z	Endevco	7264-2000T	J18664	Up
CSTXD1	Chest	X	Servo	14CB1-2897	83672-14	Outward
PEVXG6	Pelvis	X	Endevco	7264-2000T	AJ7R1	Rearward
PEVYG6	Pelvis	Y	Endevco	7264-2000T	J23913	Left
PEVZG6	Pelvis	Z	Endevco	7264-2000T	J21963	Up
LFMZF6	Left femur	Z	Denton	1914	0260FZ	Tension
RFMZF6	Right femur	Z	Denton	1914	0261FZ	Tension

## Vehicle Instrumentation Placement

Test Number 990421-1

<u>Number</u>	<u>Location</u>	<u>Axis</u>	<u>Manufacturer</u>	<u>Model</u>	<u>S/N</u>	<u>Orientation (+ Sensing)</u>
1	Floor Tunnel #1	X	Endevco	7264-2000T	J22653	Forward
		Y	Endevco	7264-2000T	J27944	Left
		Z	Endevco	7264-2000T	J27651	Up
2	Vehicle Center of Gravity	X	Endevco	7264-2000T	J25465	Forward
		Y	Endevco	7264-2000T	J27797	Left
		Z	Endevco	7264-2000T	J23898	Up
3	Floor Tunnel #2	X	Endevco	7264-2000T	J21532	Forward
		Y	Endevco	7264-2000T	J27892	Left
		Z	Endevco	7264-2000T	J27800	Up
4	Floor Tunnel #3	X	Endevco	7264-2000T	J28468	Forward
		Y	Endevco	7264-2000T	J27947	Left
		Z	Endevco	7264-2000T	J22740	Up

## Report Sign Convention and NHTSA Data Tape Reference Guide

<u>Accelerometers:</u>	+X: Forward
	+Y: Leftward
	+Z: Upward
<u>Potentiometers:</u>	+Chest longitudinal deflection: Outward
	+Chest lateral deflection: Leftward
	+Seat belt displacement: Outward
	+Seat belt extension: Elongation
	+Knee slider displacement: Distance between femur and tibia increased (in relation to a seated dummy)
<u>Load cells:</u>	+Femur force: Tension
	+Seat belt force: Tension
	+Barrier force: Tension
<u>Neck load cells:</u>	+X force: Head pushed forward
	+Y force: Head pushed leftward
	+Z force: Head pulled upward (tension on neck)
	+X moment: Right ear rotating toward right shoulder
	+Y moment: Chin rotating toward chest
	+Z moment: Chin rotating toward left shoulder
<u>Tibia load cells:</u>	+X force: Ankle forward, knee rearward
	+Y force: Ankle rightward, knee leftward
	+Z force: Tension
	+X moment: Bottom of tibia moving leftward
	+Y moment: Bottom of tibia moving rearward

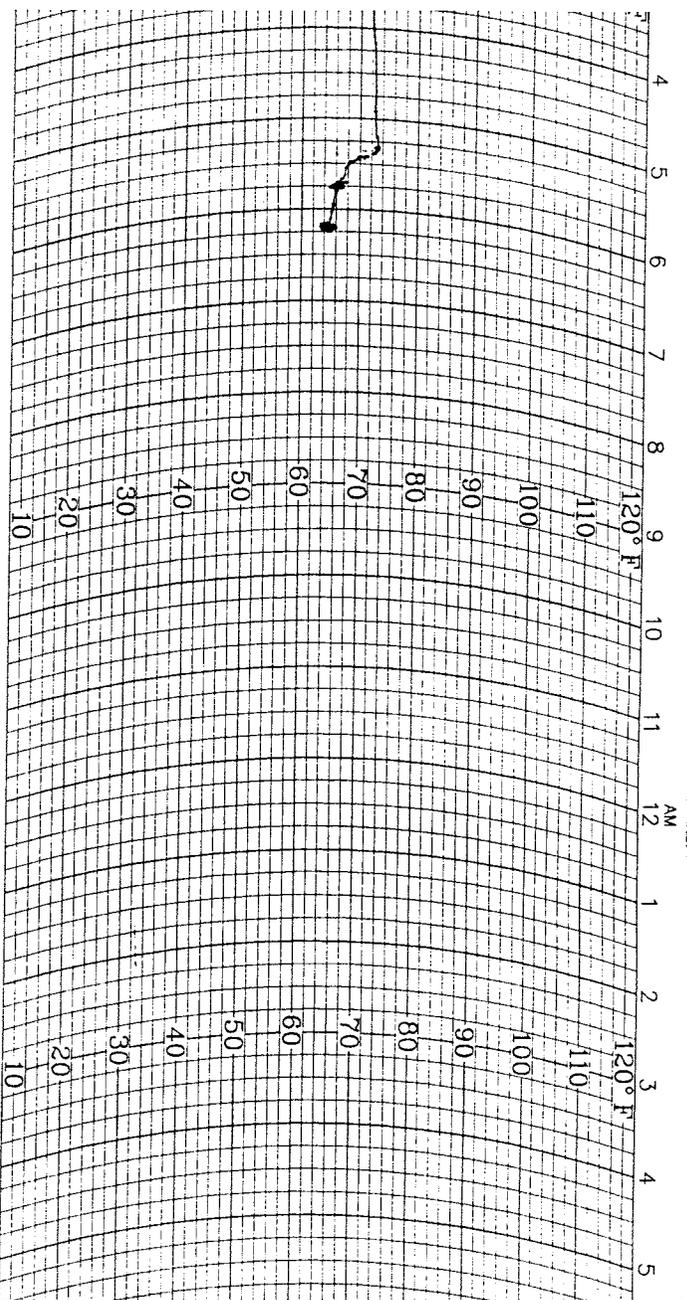
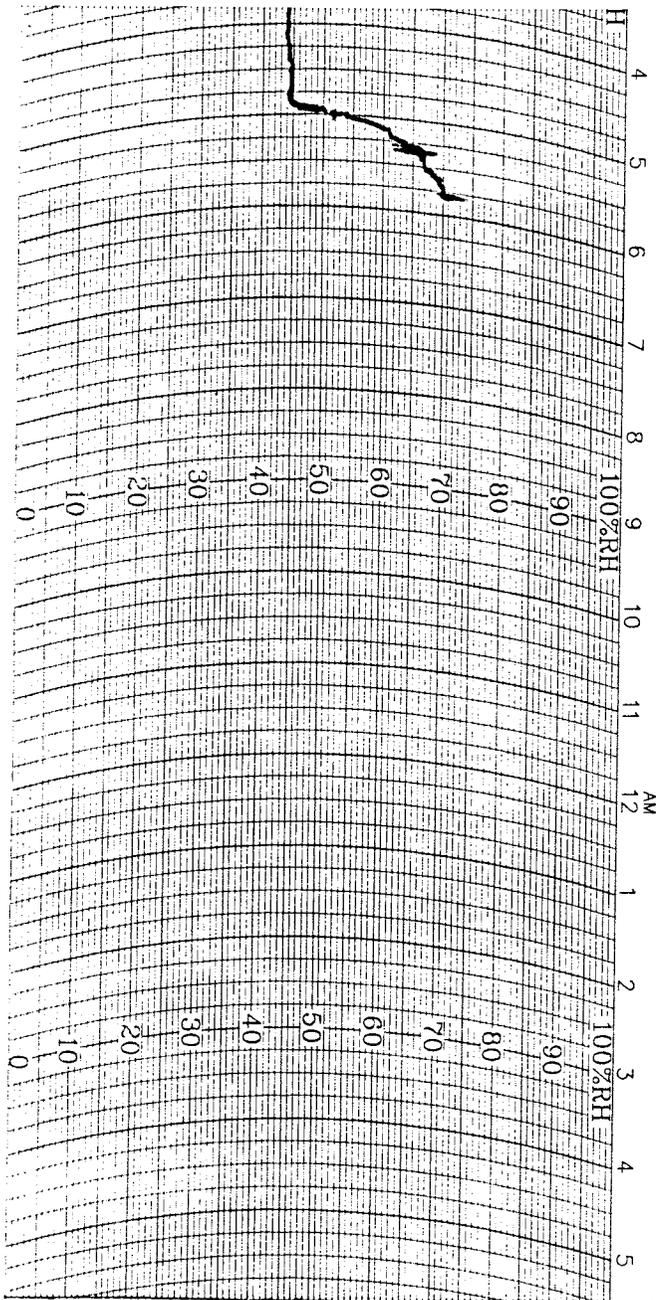
## Description Of Timing Marks On TRC High-Speed Film

All TRC high-speed cameras are equipped with red LED's, which put timing, marks on the right edge of the film. TRC uses a single timing generator to generate the timing for all cameras. This allows the timing marks to be common to all cameras. The timing marks can be used to measure camera speed (frames per second) or to locate a point in time before or after the time-zero event.

The timing marks appear on the film as small red marks on the right edge of the film. Round marks are left by the Photo-Sonics and Stalex cameras while horizontal bars are left by the Hycam, Locam, and Fastax II cameras.

The timing generator puts out a pulse for every millisecond plus it generates additional pulses for hundredths and tenths of seconds. To explain this further, we can use an example of a camera running at 1000 frames per second.

1. Every frame will have **one** LED appear in it. This indicates a *millisecond* pulse.
2. Every ten frames will have **two** LEDs appear in it. These indicate a *millisecond* pulse plus a *hundredth of a second* pulse.
3. Every one hundred frames will have **three** LEDs appear in it. These indicate a *millisecond* pulse, a *hundredth of a second* pulse, and a *tenth of a second* pulse.




**Weather Measure**  
**WEATHERtronics**  
 Division of QUALIMETRICS, Inc.

P.O. BOX 41039  
 SACRAMENTO, CA 95841  
 PHONE: (916) 923-0055

HYGROTHERMOGRAPH  
 1 DAY

CHART NO. M699123  
 C311-D-HF  
 ECN 2717  
 6-9-87

STATION \_\_\_\_\_ DATE ON \_\_\_\_\_ DATE OFF \_\_\_\_\_